STORAGE FACTORS AFFECTING SPROUTING AND PLANT DEVELOPMENT IN SEED POTATOES

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by

DILIP KUMAR DAS GUPTA, B.Sc. (Ag.), M.Sc. (Ag.)

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University Department of Agriculture,
West Mains Road, Edinburgh.

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INTRODUCTION

In Britain a progressive improvement in the health and purity of potato seed stocks can be traced since the beginning of this century, this improvement being reflected in the steady raising of standards employed in the scheme for the 'Inspection of growing crops of potatoes'. In the present day pattern of potato growing, certified seed potatoes of considerable value are produced annually from Scotland, Ireland and to a lesser extent from high lying areas of England and Wales, and the guarantee of a high degree of freedom from virus diseases, which is embodied in the certification scheme, has no doubt contributed much to the high general level of yield in our commercial varieties.

There is, however, still a considerable scope for variation in the value of seed with respect to disease factors and physiological factors as influenced by the conditions of storage. Thus blanking in crops may arise from fungal diseases such as dry rot (*Fusarium caeruleum*. Lib) and skin spot (*Oospora pustulans*. O & W) which may develop on the seed tuber during storage and there has been increasing interest in measures to control these diseases. Interest has also grown in the effect of conditions obtaining during the storage phase of the seed tuber on its sprouting behaviour and subsequent plant development.

The potato tuber is highly responsive to storage factors and its condition at the time of planting as regards weight losses sustained in storage, food reserves available for further growth and stage of sprout development may vary considerably according to the storage environment. The introduction of storage techniques to give greater control of temperature, recognised as the most important storage factor, developments in sprouting techniques and the use of sprout inhibiting chemicals all afford the opportunity to determine this condition to a much greater extent, but more detailed information is still required on storage factors in their various combinations and in their ultimate effects. To further this end, the present study has been carried out to investigate the effects of variations in storage temperature and the use of sprout inhibiting chemicals, before sprouting at various times or planting direct, on sprouting behaviour and plant development in the field.

REVIEW OF LITERATURE

Potato tubers arise as swellings of the tips of underground creeping stems, or their branches, which develop from the axils of the underground parts of the aerial stems. The swellings are at first clavate shaped, becoming globular, and then with further development gradually assume the characteristic shape of the variety. Each tuber can be regarded as a shoot structure modified for food storage and capable of further growth from its meristems to form sprouts under suitable conditions. The tuber shows all basic stem morphology with the presence of a terminal bud and spirally arranged lateral buds or eyes. The number of eyes may show considerable variation even in the same variety. Each eye of the potato tuber has a shrivelled scale leaf in the axil of which are situated at least three buds (Hector 1936).

Rest and Dormant Period

Many authors consider that after harvest the tuber goes through a period of rest (Appleman 1914, Wright and Peacock 1934, Emilsson 1949, Kawakami 1953). This rest period has been defined as that period immediately following harvest during which the potato tuber will not sprout even under optimal environmental conditions for growth (Appleman 1914, Wright and Peacock 1934, Emilsson 1949). Appleman (1914) considered the rest period to be determined largely by internal factors and that certain changes in the chemical composition of the tuber were necessary to allow bud activity to start. According to Madec and Perennec (1960a) the end of the rest period is governed by the chemical composition of the tuber reserves, and the "seat of evolution" is not the bud meristems but in the mother-tuber-reserves.

When conditions remain unfavourable for growth, the tuber requires a longer period to sprout. This has been termed the dormant period and defined as that period during which the tuber may be stored at some temperature sub-optimal for sprouting without beginning to sprout or break down physiologically (Wright and Peacock 1934, Emilsson 1949). Thus the rest period has been looked upon as being controlled by internal factors, whereas dormancy is dependent upon both internal and external factors (Wright and Peacock 1934).

Not all investigators, however, accept the concept of a true rest period in the potato tuber and there is divergence of opinion with regard to the definition of terms. Burton (1957a) has pointed out the difficulty in recognising the end of the rest period since its actual completion may occur some time before the growth of the sprout is noticeable due to the slow rate of cell division. Earlier investigations (Wright and Peacock 1934) had been concerned for the most part with the end of the rest period as evidenced by visible bud enlargement. Following detailed anatomical investigations, however, Davidson (1958b) suggested that sprout growth was continuous at the apical eyes of the tuber after harvest, but was not visible to the naked eye due to the slow growth of the buds. Rosa (1928) also described the development of bud primordia during the rest period when the storage temperature was sufficiently high.

Taking into account the different views on the rest period and dormancy, Burton (1957a) suggested that the dormant period might be regarded as beginning when cell division ceases during tuber enlargement (or perhaps when stolon elongation ceases) and ending with resumption of active bud growth under favourable conditions of storage. Thus the dormant period after harvest is an undefined portion of the true dormant period which is roughly the same for all tubers, larger or smaller, in any one crop.

Theories to Account for Breaking of Dormancy

Many theories have been propounded to explain the cause of dormancy and its cessation. Burton (1957a) summarised the different theories which have been postulated to account for the cause of dormancy as follows:- (1) from a deficiency of soluble carbohydrate (Müller Thurgan 1882); (2) interruption in oxygen supply caused by suberization of the skin (Appleman 1916); (3) high concentration of carbon dioxide in the tuber (Kidd 1914); and (4) presence of an acid growth inhibiting substance (Hemberg 1947, Hemberg 1949). Cessation of dormancy has been associated with the increase in glutathione in the tuber (Emilsson 1949). While attempts have been made to correlate the breaking of dormancy with some definite changes in the biochemical balance in the tuber, investigations of the major constituents of the tuber have, for the most part, given negative results. Thus no relationships have been established between sprouting and sugar content, the extent of protein hydrolysis (Appleman 1914, 1916, Appleman and Miller 1926), the activity of several enzymes (Appleman 1916, Appleman and Miller 1926) or concentration of oxygen and carbon dioxide (Burton 1950, 1952a). The theory of the presence of acid growth inhibiting substances (Hemberg 1947, 1949) to account for the control of dormancy was criticised by Burton (1956a) on the grounds that to assess a substance as a potato sprout inhibitor on the basis of its effect on Avena coleoptiles as used by Hemberg was unjustified, and that the effects of variety and storage temperature upon growth promoting and growth inhibiting substances in the potato do not necessarily bear any relation to the effects of these variable factors on sprouting.

Burton (1952b) indicated that volatile metabolic substances other than Co_2, such as ethylene, produced by the potato prevent potato sprouting and may be related to the dormancy of the potato tuber. It was subsequently suggested that the rate of production of such volatile substances and their concentration in solution in the cell sap throughout the life of the tuber may be relevant to an explanation of dormancy (Burton 1957a). Later, Burton (1958) considered that there was a parallelism, and possibly a causal connection, between the suppression or natural reduction of the activity of a terminal oxidase system sensitive to changes in oxygen tension (i.e. other than cytochrome oxidase) and the occurrence of sprout growth. The link between the terminal oxidase system and dormancy could conceivably result from the by-products of the system - the sprout inhibiting volatiles mentioned above (Burton 1960).

Notwithstanding the divergence in views relating to principles underlying the rest and dormant periods of the tuber, several factors are generally recognised from a practical view-point to affect the time when visible sprouting commences, viz. variety, maturity, temperature, light, humidity of storage and growth regulating substances.

(a) Variety. Ophuis (1957) in the Netherlands reported that the rest period, when tubers were held at a constant temperature of about 20°C, varied from several weeks to several months according to the variety. Burton (1948) in reviewing ~~with~~ British varieties, indicated that earlies, such as Arran Pilot and Ninetyfold, were characterized by a short period of dormancy while other varieties, such as Golden Wonder and Arran Consul, were late to commence sprouting even under quite favourable conditions for growth. Earliness in sprouting, however, is not necessarily related to maturity class: some main crop varieties, such as Ulster Grove, can behave very much like Arran Pilot in their time of sprouting while some first earlies, such as Ulster Prince and Craigs Alliance, often tend to be slow to start growth (Owers 1960). From field experiments Slomnicki (1961) reported that varieties having a short dormant period produced sprouts above ground earlier than those having a long dormant period.

(b) Maturity. Earlier development of sprouts has been related to maturity of tubers. Thus Rosa (1928) found that when tuber maturity was determined by time of lifting, the average number of days required for the sprout to develop was greatest in the sample harvested earliest and decreased gradually with the period of harvesting, being shortest in the sample dug at the latest date. Loomis (1927) and later Emilsson (1949) reported that in any one sample small tubers sprouted less readily than large ones and Loomis (1927) suggested that this might be related to the immaturity of small tubers.

(c) Temperature. The temperature of storage is accepted to be the most important environmental factor affecting sprouting behaviour. Ophuis (1957) reported that sprouting was retarded with decreasing temperatures below 20°C (68°F) and that sprouting could be suppressed for several months (6-8 months) by storage at a suitably low temperature (4°C, i.e. 39.2°F). This author further commented that the most vigorously sprouting varieties remained dormant for three months after harvest when they were successively stored at 13°C (55.4°F), 10°C (50°F) and 6°C (42.8°F) during these three months. According to Jong (1961) at 35°F (2°C) tubers would wither after a period of two to three years without ever having sprouted.

The effect of storage temperature upon sprout growth is, however, at least twofold, direct by influencing the rate of cell division and enlargement, and indirect by its influence upon the composition of the substrate (i.e. the tuber) from which the sprouts grow. Both effects are complex. For example, the content of sugar, growth inhibiting and growth promoting substances, and the activity of different enzymes in the tuber are all subject to variation and it is therefore quite possible that storage at a temperature unfavourable to sprout growth may so alter the tuber that on subsequent transfer to a favourable temperature sprouting would be accelerated above that of tubers stored continuously under favourable conditions. Thus, greatly fluctuating the temperature of storage tends to break dormancy. In this connection, Snell (1932) reported that the rest period can be shortened by storage for eight days at 86^{o}-89^{o}F (30^{o}-32^{o}C); eight days at 33^{o}-35^{o}F (1^{o}-2^{o}C) and finally another eight days at 86^{o}-89^{o}F (30^{o}-32^{o}C). However, varieties may differ in their response to fluctuation of temperature of storage. Schippers (1955) reported that in the variety Alpha (a slow sprouting variety) the period of dormancy could be shortened by fluctuating the temperature with alternate days at 35.6^{o}F (2^{o}C) and 68^{o}F (20^{o}C), or 86^{o}F (30^{o}C), for three weeks after harvest and then at 68^{o}F (20^{o}C) constant. In Vora (a rapidly sprouting variety) the period of dormancy was shorter when the tubers were stored at 35.6^{o}F (2^{o}C) for three weeks and then at 68^{o}F (20^{o}C) or at 68^{o}F (20^{o}C) constant from the time of harvest.

(d) Light and Humidity. Light and humidity of storage have also been reported to affect the time when sprouting starts, although the evidence is limited. Appleman (1914) reported that subdued light hastened the initiation of sprout growth on new tubers with slightly suberized skins, whereas the beginning of sprouting in mature tubers exposed to light was retarded. Emilsson (1949) found that tubers sprouted earlier during storage at high humidity than at low humidity. Considering the effects of temperature, light and humidity upon the commencement of sprouting, Davidson (1958b) observed that temperature played the most important role in controlling the length of the period from harvest to the point of minimal visible sprouting (2 mm.) while light had no effect and humidity had some little effect at lower temperature.

(e) <u>Growth Regulating Substances</u>. The rest period can be shortened by various chemical treatments and such substances as ethylbromide vapour, hydrogen peroxide, methyl disulphide, ethylene chlorohydrin, hydrogen sulphide and gluthathione applied to lifted tubers have been found to stimulate sprouting (Burton 1957a). This stimulation is important in countries where more than one crop is taken in succession, where freshly harvested tubers are imported for immediate planting or in cases where early plant growth from a sample of tubers would assist disease assessment for certification purposes. Amongst all of these chemicals ethylene chloro-hydrin treatment has probably proved the most effective means of stimulating sprouting in practice.

On the other hand, many chemicals with growth inhibiting properties are known to prolong the dormant period and of these several have been developed commercially to suppress sprouting in storage, notably (a) Tetrachloronitrobenzene (T.C.N.B.), (b) Methyl alphanapthylacetate (M.A.N.A.), (c) Isopropylphenylcarbamate (I.P.P.C.), (d) Maleic hydrazide (M.H.) [Perlasca 1956], (e) Nonyl alcohol (Nonanol) [Burton 1956b].

The first three of these are all volatile compounds which are usually applied to the harvested tubers in the form of dusts and exert their effect in the vapour phase. In Britain, T.C.N.B. is the only sprout suppressant dust to have been used on a relatively wide scale in practice. This might be related in part to its fungicidal properties providing control of dry rot, and also to the fact that it can be used on seed potatoes. The effect of suppression disappears as soon as the active principle is removed from the treated tubers and the sprouts which have been retarded in growth by the dust will then begin to grow at the same rate as untreated sprouts. The reduction in sprout growth is greater the lower the temperature of storage and the earlier the application of the dust (Brown and Reavill 1954).

M.A.N.A., which has been used extensively in the U.S.A., has never developed beyond the experimental stage in this country, being considered uneconomical in practice (Wilson and McKee 1948). It is, moreover, not suitable for seed potatoes (Perlasca 1956).

I.P.P.C. is also unsuitable for seed potatoes due to its adverse effect on subsequent sprouting (Downic 1952, Mattingley and Downic 1953, Nuttsch 1958 and 1959). Although I.P.P.C. and its derivatives are used in some continental countries, its use in this country has been limited: one disadvantage to its use is that it inhibits cork cambium activity in the tuber and may aggravate certain skin diseases such as skin spot (Ives 1955).

Foliar applications of Maleic hydrazide to the growing crop are used extensively in the U.S.A. to suppress subsequent sprouting of tubers (Perlasca 1956), but this chemical has not been used on a commercial scale in this country. In Britain, Burton (1956c) suggested that the use of Maleic hydrazide is not ideal from the growers point of view, in that the time of application is fairly critical, the yield and quality may be affected, and the weather after spraying influences the effectiveness of treatment. Moreover, it cannot be used on crops for seed production (Perlasca 1956).

Nonyl alcohol is applied as a vapour to potatoes in store, but again it is suspect for seed tubers due to its toxic effect on developing sprout tissue (Twiss 1960). Twiss (1960), however, has suggested the possibilities of amyl alcohol which is apparently less toxic to sprouts, but so far there is no positive evidence on the practical use of this compound for seed potatoes.

Number of Sprouts per Tuber

A tuber has many eyes and each eye is capable of producing one or more sprouts. The actual number of sprouts which does develop, however, is found to depend on a number of factors including (a) age, (b) variety, (c) seed size, and (d) previous removal of sprouts.

(a) Age. After passing through its rest period, and under favourable conditions for growth, the tuber tends to produce a single sprout from the apical eye only with a suppression of sprout growth from other eyes. This stage is called the apical dominant phase or single sprouting stage (Appleman 1925, Kawakami 1953, Toosey 1959). Where there is a delay in sprouting, the number of sprouts increases with the age of the tuber. Kawakami (1953) considered that most potato varieties in Japan arrive at their one sprouting stage three months after harvest; in 4-5 months they have reached the two sprouting stage and after about 6-7 months they are in their 3-4 sprouting stage.

Delay in the time of sprouting may be affected by low temperature storage or by chemical methods of sprout suppression. Thus seed potatoes placed out to sprout in light at high temperature, stored previously at low temperature, showed a loss of apical dominance and thereby an increase in degree of multiple sprouting (Bushnell 1929, Hiele 1961). Toosey (1959) also reported that when sprouting was delayed until late winter the seed potatoes passed to the multiple sprouting phase and produced several sprouts per set. Growth regulating substances used either for the interruption or prolonging of dormancy frequently increase the number of sprouts. This has been observed after the application of Giberellic acid and Maleic hydrazide (Hiele 1961); Thiourea (Woodbury 1938, Hiele 1961); T.C.N.B. (Brown and Reavill 1954, Hiele 1961).

The number of sprouts per tuber may also be influenced by maturity. Mature tubers have been found to produce more sprouts than immature tubers when the difference in maturity is due to the time of planting the preceding season (Bushnell 1929).

(b) Variety. Varietal differences in the number of sprouts formed per tuber have been observed but may also be related to the time of sprouting. Toosey (1959) reported that Stormont 480 (a vigorous sprouting variety) formed more or less the same number of sprouts as King Edward when they were sprouted during early autumn, but delay in sprouting resulted in a greater number of sprouts in Stormont 480 compared with King Edward.

(c) Seed Size. The size of the potato tuber is also an important factor influencing the number of sprouts (Appleman 1918) and several workers have shown that the number of sprouts per tuber increased with an increase in seed size (Aicher 1920, Bushnell 1929, Bates 1935, Toosey 1959).

(d) Previous Removal of Sprouts. If the first formed sprouts are removed or for any reason retarded in their normal growth, sprouts will appear from other eyes of the tuber. Similar behaviour is also found within an eye when an eye represents a collection of several buds and thus when the dominant sprout in an eye is destroyed or retarded in growth other buds in the eye become active (Appleman 1918, 1925). Several authors have indicated that the removal of sprouts resulted in a loss of apical dominance and that the number of sprouts subsequently formed was greater than that of comparable tubers where the first formed sprouts had remained intact (Bushnell 1929, Toosey 1959, Hiele 1961).

Sprout Growth

The growth curve of sprouts under a given environment follows a classic sigmoid pattern where the criterian is taken as either length or weight (Madec and Perennec 1960a). Following the commencement of visible bud enlargement at the eyes, however, the subsequent growth of the sprouts may show considerable variation according to variety, tuber age, seed size and the environmental conditions of storage, particularly temperature and light.

(a) Variety. As the time when visible sprouting starts depends upon variety, so the growth rate of sprouts also depends on variety. Varietal differences in rate of sprout growth have been indicated by Burton (1957a): such varieties as Home Guard and Craig's Defiance, which sprout soon after harvest, exhibit a very rapid rate of growth, whereas Arran Consul and Golden Wonder have a slow rate of sprout growth. The rates of sprout growth of most commercial varieties in Britain fall between that of Arran Consul on the one hand and Home Guard or Craig's Defiance on the other. Earliness in sprouting or faster rate of growth of sprout, however, is not necessarily related to maturity class. Isleib and Thomson (1959) reported that an early variety, Tawa, exhibited a slow rate of sprout growth, whereas Saco, a late variety, showed a quicker rate of growth.

(b) Age. From the time of lifting onwards to a certain stage the "Germinating power" of the potato tuber (as measured by the weight of sprouts produced during a period of four weeks at a constant temperature at 20°C, i.e. 68°F, following previous storage at 2°C, i.e. 35.6°F) has been shown to increase with age and reaches its maximum about 12 months after lifting (Krijthe 1958). After some twelve months, the germinating power was found to decrease, although the tubers had not suffered from loss of sprouts.

Burton (1952c) reported that the weight of sprouts produced by non-dormant Majestic tubers (stored at 5°C, i.e. 41°F, from October to February) after 73 days at 10°C (50°F) was six times as great as that produced after 105 days at the same temperature by tubers initially dormant (sprouted in October). Burton's observation may again be related to age where the ability to produce sprouts by a tuber increases with the age.

(c) Size of Seed Tuber. Vigour of sprout growth also depends upon the size of tuber or, in other words, upon the amount of tissue surrounding the growing bud. Headford (1962) reported that growth in dry weight of sprouts from tuber pieces was directly proportional to the size of the attached tuber piece (varied from 1 to 64 gm.). These results were further supported by another experiment by the same author in which the number of sprouts (1, 2 or 4) from tubers of a constant size (80 gm.) was varied and it was found that the weight achieved by individual sprouts was inversely proportional to the number developed. Headford (1962) suggested that nitrogen might be the component of the tuber substrate limiting growth of sprouts and there was a positive correlation between sprout size and percentage total nitrogen. Appleman (1918) also has indicated that if seed size fell below a certain minimum weight, the sprout became weaker as the size of the piece decreased.

(d) Temperature. The temperature of storage is the most important environmental factor affecting the growth of sprouts. Barker (1937) reported increases in the rate of sprout growth occurred by increasing the temperature of storage from $5^{o}C$ ($41^{o}F$) to $15^{o}C$ ($59^{o}F$) but above that the increase was less marked. From the results of field experiments, Isleib and Thomson (1959) suggested that at $46^{o}F$ ($7.7^{o}C$) the growth of sprouts and roots was very slow and an increase in temperature to 60°F (15.5°C) resulted in increases in growth of sprouts and roots. The author considered 48°-50°F (8.8°-10°C) to be a critical growth temperature for excellent sprouting and reasonable root growth for potato seed.

Recently Headford (1960 and 1962) reported that in King Edward and Arran Pilot, increase in temperature of storage from 4° to 25°C (39.2° to 77°F) resulted in an increase in the rate of sprout growth and further increase in temperature to30°C (86°F) caused a decrease in the growth rate due to the death of sprout apex. The growing points also died after some months storage at 20°C (68°F) and at 25°C (77°F), and as a result the longest sprouts were finally produced at 15°C (59°F). Headford (1960 and 1962) further considered that different varieties may vary somewhat in their growth response at different temperatures. However, the broad picture of rate of sprout growth at a constant temperature is the same and when the tubers are transferred from a low to a high temperature, or vice versa, the growth rate typical of that temperature is immediately assumed.

Working with the varieties Arran Pilot, King Edward and Majestic, Owers (1960) observed that with variations in the temperature of storage, ranging 45°F (7.2°C) to 75°F (23.9°C), with fluorescent strip lighting, there was a marked difference in growth response between different varieties. While King Edward and Majestic showed some slight increase in sprout length at planting time with increases in temperature from

45°F (7.2°C) to 55°F (12.8°C) and 65°F (18.3°C), Arran Pilot showed extreme lengthening at the higher temperatures, the maximum length being attained at 55°F (12.8°C). Sprout length decreased with further increase in temperature to 75°F (23.9°C) in all varieties. Similar results have also been reported by Shotton (1961).

(e) Light. In addition to temperature of storage light also plays an important role in its effect on the sprouting behaviour of potato tubers. It is well known that sprouts grown in light are shorter and sturdier than those grown in darkness and that they develop chlorophyll. Intensive work by Wassink etal (1950a and 1950b) has indicated that light suppresses the growth in length of sprouts whereas darkness encourages it.

Headford (1962) reported that in King Edward light intensity within the range 1.07 to 28.8 cal/cm^2/day visible radiation and day lengths of 8, 16 and 24 hours had only slight effects on sprout growth during six months storage at 15°C. Although sprout length increased with decrease in total daily radiation and length of day, the minimum levels of both variables (1.07 cal/cm^2/day and 8 hours) were sufficient to prevent excessive etiolation.

Owers (1960) and later Shotton (1961) did not find any significant effect on the growth of sprouts in Arran Pilot, King Edward and Majestic sprouted in light (fluorescent tube) due to variations in day length ranging from 6 to 24 hours.

Following studies on the combined effects of light and humidity, Davidson (1958b) considered temperature and light are most important after visible sprouting began in controlling sprout growth. In the range of temperature from 45°F (7.2°C) to 65°F (18.3°C) light was stated to play the most important role, etiolation occurring in darkness. At high temperature (85°F, i.e. 29.4°C) sprout growth is mainly independent of light and humidity and is characterising by rapid initial growth followed by thickening to give a robust thick sprout. At low temperature (35°F, i.e. 1.7°C) sprout growth is slow and light access and humidity have for all practical purposes only a slight effect to the end of the normal storage period.

(f) Humidity. The humidity of the storage atmosphere may affect the rate of sprout growth, particularly when this is well advanced, and also the form of the sprouts, i.e. the degree of branching or of production of adventitious roots. Davidson (1958b) reported that high humidity (95% R.H.) in darkness at high temperature (80°F, i.e. 26.7°C) promoted growth and branching of sprouts in the variety Epicure in the latter part of the storage period (after seven months) whereas the growth and branching of sprouts in low humidity (40% R.H.) in darkness or high humidity (95% R.H.) in light at the same temperature was very restricted.

Sprout Developments

With respect to developmental changes, Madec and

Perennec (1960a) have observed that the potato sprout may pass through all stages of development, such as tuberisation, flowering and maturity, while only depending on the tuber reserves for its nutrition. Making particular reference to the tuberisation of sprouts, the authors considered that the rate of development was strongly influenced by environment, being hastened by humidity, heat and darkness, at least after the beginning of sprouting, while in the same environment sprouts of the oldest tubers were the first to develop tubers. From eye grafting and excision experiments, it was shown that the "seat of evolution" lay in the mother tuber tissues and that qualitative changes in these tissues affecting physiological development were independent of sprouting and took place at the same rate where sprouting had been artificially inhibited by chemicals, as in freely sprouting tubers. Moreover, desprouting did not suppress this development. The factor inducing tuberisation was associated with chemical changes in the tuber reserves and its formation was stated to be hastened by high temperature and delayed, but not inhibited, by low temperature. Summarising the position, three stages in the physiological evolution of the tuber reserves were distinguished: a phase of non-growth of sprouts extending from time of tuber initiation on the mother plant to the end of rest period; a phase where sprout growth was possible; a phase of non-growth of sprouts and of the growth of the daughter tuber which lasted until the exhaustion of the mother tuber. In the case of plant growth in the field, it was considered (Madec and Perennec 1960b) that where temperature and photoperiod were unfavourable for tuber induction by the foliage, the influence of the mother tuber on tuberisation might be considerable.

Joseph (1961) has indicated that the physiological and histological evolution of the seed tuber and of the sprouts may be influenced by factors operating in the production of the tuber as well as in storage. According to Went (1959) potatoes grown at a low temperature are rich in tuber forming substances and produce more and heavier potatoes than those grown at high temperatures.

Plant Growth and Development in the Field

In the foregoing discussion the behaviour of the potato tuber during storage has been described. Being a living organ the tuber is highly responsive to environmental factors during storage and these may determine to a large extent its viability and productive potential when planted. Thus subsequent growth and development (with respect to plant emergence, the number of stems developed, time of tuber initiation, the number of tubers formed and their rate of bulking and the final yield and grading of the crop) is influenced by the degree of sprout development of the seed tuber and the tuber reserves available at the time of planting (as determined by variety, the size of the seed tubers, age and storage environment).

The importance of reserve substrate from the mother tuber during the early phase of leaf and root development of the plant has been indicated by Headford (1962). In a nutrient culture experiment tubers lost 33% of their initial dry weight after 20 days and of this loss only 11% was due to respiration, the remaining 89% being translocated for plant growth. Although plants attained a leaf area of 287 cm^2, photosynthesis accounted for only 7% of the total gain in dry weight, translocation from the tuber accounting for 93%. It was previously shown by Denny (1929) that the amputation of the parent tuber at varying stages of the growth of the potato plant reduced the yield if amputation took place before the shoots were 10" high.

The amount of available substrate is determined primarily by tuber size. Thus Werner (1919) found that the rate of plant emergence was greatly influenced by the size of the seed piece and the larger the seed piece the earlier was the emergence. It was considered by many authors (Appleman 1918, Aicher 1920, Salaman 1921, 1922 and 1923, Filimanov and Rustshkina 1934, Chucka etal 1945, Hiele and Vervelde 1954) that within certain limits, and if all other conditions were the same, the rate of growth of the potato plant and the yield of tubers increased directly with the weight of the seed tuber. One suggestion offered was that the amount of food material in the parent tuber was an influencing factor, in that the larger the seed tuber the greater the initial food supply to the growing plant

(Salaman 1923).

The number of stems developed is also influenced by the size of the seed tuber, the larger the seed size the greater the number of stems per hill (Aicher 1920, Bates 1935, Chucka etal 1945, Toosey 1960). As the number of tubers produced is directly related to the number of stems per hill, there is in general an inverse ratio between the size of the seed set and the percentage of large ware in the resulting crop (Werner 1919, Aicher 1920, Clark 1921, Salaman 1921, 1922, 1923, Bates 1935, Toosey 1960). The restriction in tuber size may be attributed to the greater competition for available food supplies. Bates (1935) considered that the size of seed influenced yield and grade of produce in that it controlled the number of true plants in the hill and thereby controlled intensity of competition. According to the author, higher yield of large seed was due to a greater number of stems or plants which gave rise to a larger number of tubers.

Recently Toosey (1960) considered that the size of seed exerted a twofold influence on the growth of the potato plant. Firstly, plants from large seed benefited from a higher plane of early nutrition, were more vigorous, of superior size and tended to produce more secondary stems, the latter mainly from seed with a single sprout. Secondly, when multiple sprouted or unsprouted sets were planted, the large seed produced a greater number of plants per hill, which to some extent offset the better food supply. The twofold effect of an increase in seed size was again apparent in the grading of the produce. When sets with only a single sprout were planted, the use of large seed increased the size of the tubers. On the other hand, when multiple sprouted sets were planted, this effect was partly offset by the greater number of sprouts, giving rise to a greater number of plants, produced by the large seed. The author further considered that the size of the seed itself, regardless of the number of plants formed per hill, could influence the total number of tubers that were set.

With regard to the age of the seed tuber, the time of lifting of potato tubers in Britain varies according to the season and locality, but most crops are secured between the middle of September and the first week in November. March is the normal month for beginning planting main crops in the U.K. and it is usually finished by April. In most years, however, up to 10% of the area (mainly in the north of England and Scotland) is not planted until May (Dadd 1960). Thus the normal period of storage of seed potatoes before planting ranges from five to seven months, taking into account season and locality. It has been shown by Dyke (1956) that under British conditions some loss of yield with main crops is to be expected if planting is later than about 11th April: on the basis of Dyke's figures the potential loss in yield can amount to 0.4 tons per acre per week. This reduction may be attributed to a curtailment in the effective growing period of the plant and the actual age of the tuber has not been considered as an important factor in crop production.

In other countries, however, where the age of the tuber at the time of planting may show considerable variation, importance has been attached to physiological degeneration of seed tubers. Kawakami (1962) stated that the optimum age of the seed tuber was about 4-6 months. Physiological degeneration occurred in areas in which it was difficult to produce home grown seed of this age. The author has distinguished two types of physiological degeneration, viz. (a) juvenile degeneration which occurred before the optimum age was reached as a result of unsatisfactory sprouting related to dormancy, and (b) senile degeneration that occurred after the optimum age. According to this author, long periods of storage (e.g. 9 months) affected productivity and showed 37% reduction in yield. To this was added the effect of the increased number of stems per hill and under the usual conditions of cultivation productivity would fall by 60%.

In comparing spring grown potatoes held at 40°F (4.4°C) for nine months and fall grown potatoes at 70°F (21.1°C) for three months before planting, it was found by Miller (1936) that seed tubers subjected to a long period of storage (nine months) emerged and matured more rapidly than those subjected to a short period (three months). Seed tubers in the former case produced a larger number of stems and a greater yield of tubers of small size.

Within the storage period temperature and light may be considered the most important environmental factors determining the cropping potential of the seed tuber.

Benefits from varying periods of exposure of seed tubers to temperatures above 40°F (4.4°C) have been noted by several workers. Peacock and Wright (1927) and Stuart and Lombard (1929) reported that dormant tubers held at high temperature (50°F, i.e. 10°C, to 70°F, i.e. 21.1°C) for a short period before planting germinated better and produced larger and more vigorous stems with greater yields than those held throughout the storage period at low temperature (32°F, i.e. 0°C). According to Jehel and Heuberger (1934) seed tubers (var. Irish Cobbler) stored at low temperature (40°F, i.e. 4.4°C) until January or February and then at high temperature (65°F, i.e. 18.3°C) until planting, showed earlier emergence and faster plant growth followed by higher yield in comparison to those stored at 40°F (4.4°C) throughout the storage period.

With regard to the period of storage at higher temperature before planting, Warner (1949) suggested that continuation of initial warm storage (65°F, i.e. 18.3°C) until the rest period was almost completed followed by storage at low temperature (40°F, i.e. 4.4°C) delayed plant emergence in Triumph seed potatoes, whereas plant emergence was very rapid when initial warm storage was continued beyond the completion of the rest period. In this instance size of the plant throughout the growing period and yield were generally proportional to the rate of plant emergence.

Hartman (1934) and later Warner (1949) reported that when a constant storage temperature was used, plant emergence was more rapid and uniform with seed potatoes that had been stored in warm temperature (50°F, i.e. 10°C, to 60°F, i.e. 15.5°C) than those held at low temperature (32°F, i.e. 0°C, to 40°F, i.e. 4.4°C) again the size of the plant and the yield were found to be related to the rate of emergence.

The optimum storage temperature may, however, vary with variety. Thus Fischnich (1954) considered that German varieties fall into three classes according to their response to storage temperature. To the first class belong the varieties responding best at 4°C (39.2°F); to the second class those responding best at 7°C (44.6°F) and the third class is relatively insensitive to these storage temperatures. The author further commented that fluctuating the temperature (7°-4°-1°-4°-7°C) during winter storage proved favourable to the seeds of most German varieties and to the plants derived from them than those stored throughout at low temperature (1°C, i.e. 33.8°F) medium (4°C, i.e. 39.2°F, to 7°C, i.e. 44.6°F) or high temperature (12°C, i.e. 53.6°F).

While storage at higher temperatures may give more rapid plant development, Davidson (1958b) has indicated that final yield at maturity may be impaired. Thus plants grown from tubers stored at 80°F (26.7°C) emerged on the average fourteen days before those stored at concurrent air temperature (50°F, i.e. 10°C) and the latter emerged eight days before those stored at 35°F (1.7°C). Vigour of plants until eleven weeks after planting was related to time of emergence. Warmer storage also gave earlier tuberisation but plants matured earlier and where foliage was unimpeded by frost final yields were lower than those for cooler stored tubers.

The beneficial effects of storage at higher temperature may be related to the simulation of bud activity promoting the formation of sprouts before planting.

In practice, however, excessively long sprouts at the time of planting are undesirable in that they are easily damaged: sprout length is normally controlled by exposing the seed tuber to light at moderate temperature (47°F, i.e. 8.3°C, to 54°F, i.e. 12.2°C).

The main benefits derived from the use of sprouted seed potatoes are related to the earlier emergence and tuberisation induced by the sprouting treatment and resultant earlier bulking of the crop and possibly a greater final yield (Appleman 1918, Hanlan 1929, Hardenburgh 1928 and 1935, Filimanov and Rutshkina 1934, McCubbin 1941, Eastman and Libby 1948, Toosey 1960). Although there may be no advantage in final yield from sprouted seed where plants are allowed to reach full natural maturity, the earlier yielding capacity is an obvious advantage for early ware production where the crop is harvested before full maturity. Moreover, by bringing forward the effective growing period of the crop, sprouting can be of more general benefit in reducing losses in potential yield caused by premature defoliation due to blight or other factors or by delay in planting. In late varieties frost may also cause the foliage to die down before the plant reaches natural maturity and increased yields due to the use of sprouted seed tubers have been especially evident in late varieties and in late districts (Whitehead etal 1953).

It is possible that the potential gains from sprouting may be lost where adverse conditions such as periods of frost or drought occur at critical times in the development of the earlier growth.

The importance of the various conditions of storage are principally through their effects on the size of sprouts developed at the time of planting. Thus maximum benefit can be achieved from sprouted seed tubers having sprout lengths 5 mm. to 15 mm. long (Appleman 1918, Hiele and Vervelde 1954, Headford 1960 and 1962). According to Headford (1960 and 1962) emergence of plants and tuber initiation is earlier with increased length of sprout at planting time up to 15 mm. and longer sprouts than this give no further response.

Headford (1962) reported that there was no significant difference in the time to emergence and the initiation of tubers with both Arran Pilot (an early variety) and King Edward (a main crop variety) provided that sprouts were of the same length. Working with the variety King Edward having sprout lengths of 0.2, 2 and 5 cm., Headford (1962) found that the time of emergence was reduced with increase in sprout size. Tuber initiation, however, was most rapid from sprouts of intermediate size and the relative rates of dry weight accumulation and leaf expansion during the early period of growth decreased with increase in sprout size. This result was further supported by observation from a field experiment, where a greater weight of haulm was produced from unsprouted seed compared with sprouted tubers.

It has been mentioned in the previous discussion that within a temperature range of 45°F (7.2°C) to 65°F (12.7°C) light plays an important role in determining the growth of sprouts (Davidson 1958b). According to the early work of Krijthe (1947) for early cropping it was considered satisfactory to store seed potatoes during the entire period at 9°C (48°F) with light or at 5°C (41°F) followed by 13°-17°C (55°-62°F) with light for three weeks before planting to promote the growth of sprouts. Later, during 1948, Krijthe opposed her previous views and reported that at 5°C (41°F) and 9°C (48°F) the growth of sprouts was more vigorous in darkness and dark storage gave an earlier harvest than light storage. At 13°-17°C (55.4°F - 62.6°F) the yield was greater from storage in light.

The relative merits of exposure to light or darkness would therefore appear to be determined by the temperature. Under practical conditions, where difficulties are experienced in maintaining sufficiently low temperature to prevent excessive sprout growth, exposure to light is generally desirable. With low temperature storage, however, darkness may be beneficial for the promotion of sprout growth which, in this case, would be slow. Thus Tizio etal (1954) reported that seed potatoes stored at 7°C (44°F) in darkness gave a significantly higher yield than that for tubers stored in light at the same temperature.

Headford (1962) has shown that the differences in sprout growth after two months of storage at varying intensities of light in the range 1.07 to 28.8 cal/cm^2/day visible radiation and at day lengths varied from 8, 16 and 24 hours were insufficient to affect subsequent development and yield of the plant. While the temperature of storage of tubers exposed to fluorescent strip lighting, in the temperature range 45°F (7.2°C) to 75°F (23.9°C), has been shown to exert an influence on sprout length at planting time with marked varietal differences in response, Owers (1960) reported that yield differences for all temperature treatments were very small and it was inferred that from a practical viewpoint the temperature should be kept within the range 45°F (7.2°C) to 50°F (10°C).

The optimum period of sprouting has been shown to vary for different varieties according to their vigour of sprout growth. Thus Owers (1960) suggested that the slow sprouting varieties, such as Majestic and King Edward, needed a longer period of sprouting than a variety such as Arran Pilot which is noted for its rapidity of sprout growth. In the case of Arran Pilot, shortening the period of sprouting to 5-6 weeks hastened early plant emergence followed by early tuberisation and greater yield as compared to those held for a long period (7-8 weeks) at 50°F (10°C), whereas Majestic and King Edward (slow sprouting) responded more favourably when seed tubers were sprouted for the long period (7-8 weeks). According to the author, the time of sprouting of a particular variety should be based on its characteristic sprout growth rate. The greater the rate the longer should the start of sprouting be delayed.

Grikhestik (1941) reported that sprouting seed potatoes of early, medium and late varieties for 5-6 weeks in light at 12°C (53.6°F) to 18°C (64.4°F) before planting resulted in earlier bulking and higher yield than from unsprouted seed tubers, and this effect was marked in the case of late varieties. It seemed that when the temperature of storage was high, the late variety showed beneficial effects of sprouting even when they were sprouted for 5-6 weeks, whereas this effect was less marked in the case of early varieties, probably due to excessive sprouting.

When sprouted seed tubers are planted, the broad picture of plant development is that the number of plants, or mainstems, and tubers per hill increases with increase in sprout number and reaches a maximum when seed with multiple sprouts is planted. In contrast both vegetative development and tuber production of the individual plants are increasingly restricted as plant density within the hill rises. The single plant from seed with one sprout shows a higher degree of branching and secondary stem development with vigorous tuber production. On the other hand, the plants from multiple sprouted seed show a much lower degree of development and produce many small sized tubers. The effect of sprouting treatment is substantially modified by the variety. Varieties differ greatly in the number of sprouts that become active and in the number of plants and tubers that they produce. At one extreme, Majestic produces relatively few plants and tubers from multiple sprouted seed, and at the other extreme Stormont 480 produces an excessive number of plants and tubers per hill from multiple sprouted seed (Toosey 1960). Clark (1921) has also shown that there are marked differences between varieties in the number of plants, in the numbers of tubers per plant and therefore the number of tubers per hill.

The relationship of the number of sprouts per set and the number of plants or stems per hill has been explained by Bates (1935). He states "Each seed tuber normally gives rise to several sprouts which reach maturity, but it is not generally realised that the shoot into which the sprout develops must in time become an individual plant having independent existence".

Apart from varietal differences in stem and tuber formation per hill, period of sprouting in light before planting also plays an important role in stem and tuber formation. Thus Hardenburgh (1935) reported that in Green Mountain and White Rural varieties the number of stems as well as the number of tubers per hill decreased as the period of sprouting was increased from two to six weeks at 50°F (10°C). The effect was explained by the fact that the earlier the seed tubers were taken from storage, the more marked was the character of apical dominance.

Recently Toosey (1962) has shown that delay in sprouting in light at 54°F (12.2°C) to 65°F (12.7°C) caused an increase in sprout number followed by increased number of stems and tubers per acre in King Edward. The yield of large sized tubers (2½"-3" and over 3") was inversely proportional to stem number, whilst yield of small sized tubers (1¾"-2½" and 1¾") varied directly with stem number. Moreover, total yield was greater from early sprouted (December) seed than from seed sprouted during February.

When comparing stem numbers produced from sprouted and unsprouted seed, Bushnell (1929), working with Russet Rural variety, found that sprouting before planting increased the number of stems under field condition above that of unsprouted seed. A similar result was also obtained by McCubbin (1941) who observed that sprouted tubers produced a greater number of stems and tubers than unsprouted seed. Other workers, however, have found that sprouted seed gave fewer stems than unsprouted tubers. Hartman (1934) showed that tubers stored at 50°F produced a smaller number of stems per hill than unsprouted seed (stored at 32°F,

$35^{o}F$ and $40^{o}F$). Both total yield and yield of large sized tubers was greater from seed tubers sprouted at $50^{o}F$ than those from unsprouted seed. Working with the varieties Green Mountain and White Rural, Hardenburgh (1935) reported that sprouting seed before planting (2-6 weeks at $50^{o}F$) resulted in a significantly smaller number of stems compared with unsprouted seed. Sprouting before planting, however, caused an increase in the number and weight of stolons, number of tubers per stem and yield of marketable-sized tubers.

The divergences in the results of these earlier workers with respect to stem numbers may be related to possible differences in the number of sprouts developed on sprouted tubers. More recently, Toosey (1962) has reported that unsprouted seed tubers formed a larger number of stems per acre than early sprouted seed (December) having one sprout per tuber and a smaller number of stems than late sprouted seed (February) having four sprouts per set. Both the number and total yield of tubers was greater in both early and late sprouted seed than in unsprouted. Early sprouted seed, however, formed a greater amount of ware sized tubers ($1\frac{3}{4}$"-3") than unsprouted, whereas late sprouted seed gave rise to a smaller amount of ware than unsprouted seed.

The effects of removing sprouts, or of sprout loss, have been investigated by various workers. Removal of sprouts $\frac{1}{4}$ to 1 inch long (McCubbin 1941) and removal of sprouts from seed tubers that had been sprouted for 4-6 weeks before planting (Filimanov and Rutshkina 1934) was found to cause delayed plant emergence followed by slow plant development, tuberisation and rate of bulking in the first half of the growing season when compared with those planted with sprouts intact, although the final yield showed no difference. Appleman (1925) and McCubbin (1941) observed that desprouted seed tubers produced a greater number of stems, and also tubers, than sprouted seed which they attributed to the effect of desprouting on apical dominance. Toosey (1962) has also shown that desprouted seed formed larger numbers of stems per acre than sprouted seed (sprouted in December and February); however, the number and yield of tubers per acre was greater in the latter case. December sprouted (single sprouted) seed gave rise to a larger proportion of ware ($1\frac{3}{4}$"-3") than those desprouted but the latter produced a greater amount of ware than February sprouted (multiple sprouted) seed.

It may be noted from the results of Toosey (1962) that in spite of having a larger number of stems per hill the desprouted or unsprouted seed did not give rise to a greater number of tubers compared with sprouted seed. In this connection, account may be taken of a previous observation (Toosey 1960) that the single plant from seed with one sprout shows a higher degree of branching with more vigorous tuber production than those from tubers with multiple sprouts. It would thus seem that underground branches from the main stem in sprouted seed may play an important role in the formation of tubers. Another factor to be considered is the number of underground nodes developed. A larger number of nodes would result in sprouts developed in light from sprouted seed giving rise to a larger number of stolons and tubers: in unsprouted or desprouted seed the formation of underground nodes on the stems would be restricted due to etiolation in growth in the soil. Thus Hardenburgh (1935) reported that the sprouted tuber gave rise to a larger number and weight of stolons and also a larger number of tubers per plant than unsprouted seed. According to Hiele (1961) etiolated sprouts form fewer subterranean internodes, stolons and tubers than sprouts formed in the light.

In considering the effect of removal of sprouts before planting McCubbin (1941) showed that desprouted seed tubers (sprouts of $\frac{1}{2}$ to 1 inch removed) emerged and matured much more quickly than dormant seed (stored at $36^{o}F$, i.e. $2.2^{o}C$, throughout). Earlier emergence followed by earlier maturity in desprouted seed compared with dormant tubers might be related to the effect of temperature on the physiological development of the tuber in the former case. It was suggested by Madec and Perennec (1960a) that the growth and development of the sprout was governed by the physiological age of the tuber, this itself depending upon the actual age and also on the environmental conditions during storage. Making particular reference to tuber formation on sprouts, the author considered that the rate of development was strongly influenced by environment, being hastened by humidity, heat and darkness, at least after the beginning of sprouting. The stimulus leading to tuberisation was associated with chemical changes in the tuber reserves and its formation was stated to be hastened by high temperature and delayed, but not inhibited, by low temperature. Thus the earlier development of desprouted tubers compared with dormant tubers stored at a temperature low enough to prevent sprouting may be related to the influence of a higher temperature (allowing sprout growth) in the storage of tubers from which sprouts are subsequently removed.

With regard to yield and stem number, McCubbin (1941) has shown that desprouted seed gave rise to a larger number of stems and tubers than dormant seed but the increased yield in desprouted seed over that of dormant was not significant. These results are in close agreement with those of Toosey (1962) who showed that desprouted seed (stored in sacks in unheated store from October and desprouted before planting in April) formed a larger number of stems and tubers per acre than dormant seed (stored throughout at 36°F, i.e. 2.2°C). However, the difference between these two treatments in total yield and yield of ware was not significant.

In a comparison of yielding capacity of sprouted, desprouted and dormant seed, McCubbin (1941) considered that the final yield in weight of tubers would depend primarily on time of planting, the length of the growing season and climatic conditions. With early planting or a growing season sufficiently long to permit plants of the three seed treatments (sprouted, desprouted and dormant) to attain complete maturity under equally favourable climatic conditions, yield would no doubt be equal. With late planting or a short growing season in which the plants of all seed treatments were killed by frost or blight before maturity, yield would probably be highest from sprouted, intermediate from desprouted and lowest from dormant seed.

Resprouting of seed tubers after removal of sprouts has a beneficial effect on the development and yield of the potato plant compared with that of tubers not resprouted (McCubbin 1941, Fischnich 1954). McCubbin (1941) reported that seed tubers with one crop of sprouts (1.21 cm.) removed and planted with a second crop (sprout length 1.53 cm.) emerged and matured as early as those planted with the first crop of sprouts intact (sprout length 1.15 cm.). Resprouted seed produced a significantly greater number of stems and tubers per plant than that planted bearing the first crop of sprouts. The difference in total yield and yield of large sized tubers was, however, not significant (McCubbin 1941, Fischnich 1954).

Desprouting seed tubers more than once has been reported by several workers to have an adverse effect on crop yield relative to that from unsprouted tubers. Germann (1960) reported that under similar storage conditions when the same total weight of sprouts was produced during a given period of time, desprouting three times gave more reduction in yield than desprouting once. Westover (1928) has shown that the removal of sprouts once (stored for 48 days at $65^{o}F$, i.e. $12.7^{o}C$, desprouted and then transferred to $39^{o}F$, i.e. $3.9^{o}C$, until planting time) caused 6.0% loss in weight before planting and reduced yield compared with unsprouted seed (stored throughout at $39^{o}F$, i.e. $3.9^{o}C$) where 1.3% loss in weight was sustained before planting, but the reduction in yield was not significant. The reduction in yield was significant when the sprouts were removed twice (desprouted once after 48 days and again after 26 days at $65^{o}F$, i.e. $12.7^{o}C$, and then transferred to $39^{o}F$, i.e. $3.9^{o}C$, until planting) causing a loss in weight of 11.3% or more than twice. Westover (1928) noted that it was questionable if tubers which have had the sprouts "rubbed" from them more than once were of much value of seed stock.

According to Appleman (1925) repeated desprouting resulted in a decrease in sprout vigour associated with loss of apical dominance and plants from weak sprouts were correspondingly weak. Removal of sprouts once or twice appeared to have little effect on sprout vigour but further desprouting up to four times gave a decreasing vigour with a sudden drop when sprouts were removed more than once. Appleman (1925) concluded that at least four crops of sprouts two or three inches long may be removed from potatoes (var. McCormick) in storage without materially affecting their seed value when the tubers were cut before planting, but if the tubers were planted whole they may produce too many stems per hill. Too many stems per hill would result in a high percentage of calls (small tubers) in the crop. From another experiment Appleman (1925) had shown that seed tubers (Irish Cobbler) desprouted twice produced a greater number of small sized and a smaller number of large sized tubers than seed having the first crop of sprouts intact or first crop removed.

Repeated desprouting, resulting in a weakening of sprout vigour (Appleman 1925) may eventually reach a stage where tubers fail to produce any sprouts and instead new small tubers are formed directly (Appleman 1925, Krijthe 1958).

According to Germann (1957 and 1960) an unfavourable influence on yield by desprouting happened only after the germinating power of the tuber had diminished or permanent weakening of the tuber had taken place. Under normal healthy conditions of seed, however, desprouting before planting does not adversely affect plant development and desprouted seed proved better in its yielding capacity than dormant seed (McCubbin 1941 and Fischnich 1954). Where short sprouts are removed before planting, the resulting delay in emergence, subsequent growth and maturity resulting from desprouting may be related to the loss of the sprout as a plant part rather than loss of food reserves or growth substance (McCubbin 1941). The handicap of desprouted seed lies in the slow rate of plant development compared with that of sprouted seed and according to McCubbin this can be overcome by resprouting the seed tuber before planting.

Of the sprout inhibiting chemicals which are available for suppressing excessive sprout growth in storage, only T.C.N.B. has proved satisfactory for seed tubers.

Brown and Reavill (1954) carried out an intensive study with T.C.N.B. and found that T.C.N.B. treated tubers, sprouted in light several weeks before planting, emerged as early as control seed (i.e. without T.C.N.B. and sprouted in light) whereas those stored throughout the storage period with T.C.N.B. emerged later than those stored throughout in clamps without T.C.N.B. The subsequent growth and development of the plant was related to the rate of emergence; however, the yield differences between treatments were less obvious at the late lifting. Brown and Reavill (1954) suggested that a period of seven weeks of airing is required for T.C.N.B. treated tubers to become equal in yielding capacity to the chitted control (stored without T.C.N.B. and sprouted in light at the same time when T.C.N.B. treated tuber was aired). T.C.N.B. treatment caused the formation of a greater number of stems and also tubers of seed size and as a result the ware/seed ratio was reduced by T.C.N.B. treatments.

Downic (1950) indicated that treatment of seed potatoes with T.C.N.B. tended to depress the germination of plants, although the author suggested the possibility of the application of T.C.N.B. for seed potatoes as it controlled dry rot disease during storage.

From the foregoing findings of earlier investigators, it may be inferred that apart from the varietal differences the sprouting behaviour of the potato tuber is influenced to a large extent by the different environmental factors during storage and this in turn can modify to a considerable extent the subsequent plant development in the field.

In the usual system of potato production in this country, seed potatoes are generally stored in bulk and may subsequently be sprouted in light or planted direct from bulk storage. The conditions in bulk storage may vary according to method and season resulting in a variation in the sprouting condition of the seed tuber at the time of sprouting or before planting. With a view to acquiring more information regarding the reaction of seed potatoes under different environmental conditions during storage and the subsequent effect on sprouting behaviour and plant development in the field, the following experiments were carried out during the course of investigation.

(1) Effect of varying the periods of storage of seed tubers with T.C.N.B. or at low temperature (40^{o}F) on subsequent sprouting in light and plant emergence in the field.

(2) Effect of varying the periods of storage of seed tubers with T.C.N.B. or at low temperature (40^{o}F) on

subsequent sprouting in darkness and plant emergence in the field after desprouting before planting.

(3) Effect of desprouting after varying periods of storage on sprouting in the light or darkness and on plant emergence in the field.

(4) Effect of varying periods of storage at different temperatures and with or without T.C.N.B. on subsequent sprouting behaviour and plant development of seed potatoes.

(5) Effect of length and periods of storage at high temperatures on weight losses in storage and subsequent plant development of seed potatoes.

PART 1

E X P E R I M E N T S

1959-60

The following studies were carried out during the period October 1959 to June 1960:-

Experiment 1. Effect of varying the period of storage of seed tubers with T.C.N.B. or at low temperature (40°F) on subsequent sprouting in light and plant emergence in the field.

Experiment 2. Effect of varying the period of storage of seed tubers with T.C.N.B. or at low temperature (40°F) on subsequent sprouting in darkness and plant emergence in the field after desprouting before planting.

Experiment 3. Effect of desprouting after varying periods of storage on sprouting in the light or darkness and on plant emergence in the field.

MATERIALS AND METHODS

The studies were carried out on the varieties Arran Pilot and Majestic and seed tubers of Scottish Grade A Stocks were used for the experiments.

Storage Treatments

(a) Experiments 1 and 2 - For Experiment 1 a sample of 12 tubers of each variety was placed on a tray in a glasshouse for sprouting in light throughout the storage period (October - April). Similar samples for Experiment 2 were transferred to a tray in the glasshouse and covered with black paper for sprouting in darkness over the same period. The temperature of the glasshouse ranged from 48°F (Minimum) to 70°F (Maximum) over the total sprouting period (Appendix I).

At the beginning of the experiments (19th October, 1959) five further samples of 24 tubers of each variety were dusted with Fusarex (3% Tetra-Chloronitrobenzene) at the rate of 9 gms. per 24 tubers and stored separately in lidded tin boxes (10" x 9.5" x 4.8") in a storage building where the temperature ranged from 33°F (Minimum) to 50°F (Maximum) over the storage period (Appendix I). On the same date other samples of tubers were transferred in open trays (23.5" x 12.0" x 3.0") to a controlled temperature room held at 40°F. At approximately four week intervals samples of 24 tubers of each variety were taken from the storage building and cold room respectively and 12 tubers of each sample placed in trays in the glasshouse for sprouting in light (Experiment 1) and 12 for sprouting in darkness (Experiment 2). Twenty-four undusted tubers of each variety were also held in tin boxes in the storage building from the beginning of the experiments and of these half were sprouted in light and half in darkness respectively after removal of sprouts at the time when the last T.C.N.B. treatment was removed. Tubers sprouted in darkness (Experiment 2) were desprouted at the end of the sprouting period (23rd April). The various treatments of Experiments 1 and 2 are summarised in Table 1.

(b) Experiment 3 - For Experiment 3 a sample of 12 tubers of each variety was placed in a tray in the glasshouse on 22nd October for sprouting in light and a further 12 for

TABLE 1
Experiments 1 and 2
Summary of Treatments

Length of Period of Storage (days) (Commencing 19th October 1959)		Date of Sprouting in Light or Darkness	Length of Period of Sprouting in Light or Darkness *	
With T.C.N.B.	At Low Temp. ($40^{o}F$) i.e. No T.C.N.B.		Light	Darkness
-	-	22.10.59	178 days	184 days
31	31	19.11.59	150 "	156 "
57	57	15.12.59	124 "	130 "
85	85	12. 1.60	96 "	102 "
113	113	9. 2.60	68 "	74 "
141	141	8. 3.60	40 "	46 "
141 days without T.C.N.B. and then desprouted.		8. 3.60	40 "	46 "

* To the time of final observations before planting.

sprouting in darkness throughout the storage period (October - April). On the same date other samples of 12 tubers of each variety were placed for sprouting in either light or darkness after removal of the apical eyes by a shallow incision with a scalpel. Tubers of each variety were also held from 22nd October in the glasshouse in trays covered with thick black paper for desprouting at varying times. On 22nd February, 24 tubers of each variety were taken from

TABLE 2
Experiment 3
Summary of Treatments

Treatments	Date of Resprouting in Light or Darkness	Length of Period of Resprouting in Light or Darkness
Sprouted throughout.	22.10.59	185 days
Apical eyes removed and sprouted throughout	22.10.59	185 days
Sprouted in darkness from 22nd Oct. to 22nd Feb., i.e. 123 days, and then desprouted	22. 2.60	62 days
Sprouted in darkness from 22nd Oct. to 7th March, i.e. 137 days, and then desprouted	7. 3.60	48 days
Sprouted throughout (22nd Oct. - 24th April) in darkness and desprouted at the end of the sprouting period.		

covered trays and after removal of sprouts 12 tubers of each variety were sprouted in light and 12 in darkness. The same procedure was followed on 7th March. At the time of planting 12 of the remaining tubers of each variety were desprouted. The various treatments of Experiment 3 are summarised in Table 2.

From the time of the final observations, which were carried out over the period 17th to 24th April, to the time of planting (5th May) the tubers were held in the glasshouse exposed to light.

Planting and Experimental Lay-out

Tubers of Experiments 1 and 2 were planted on 5th May in 27" drills at 18" spacing and tubers of Experiment 3 were planted in 25" drills at 16" spacing on the same date.

The experimental lay-outs were all of a split plot design in a randomised block system with four replications. Each replication was divided into two main plots for the two varieties. In the case of Experiments 1 and 2 each main plot was divided into 12 sub plots of three tubers alongside each other in the same drill, representing the 12 treatments. For Experiment 3 each main plot was divided into 12 sub plots and the nine treatments were randomised in nine sub plots, the remaining three being filled up with discard tubers of the same variety. Guard rows were arranged around each sub plot with tubers previously stored in clamps of the same variety as planted. Figs. 1, 2 and 3 give the lay-outs of Experiments 1, 2 and 3 respectively.

Experimental Notes. An attack of Leaf Roll was observed 55 days after planting in plants of all experimental treatments. This infection may be attributed to a heavy infestation of green fly during the first week of April in the glasshouse. Due to the high level of disease it was not possible to follow growth studies through to plant

Fig.1 LAY OUT OF THE EXPERIMENT 1

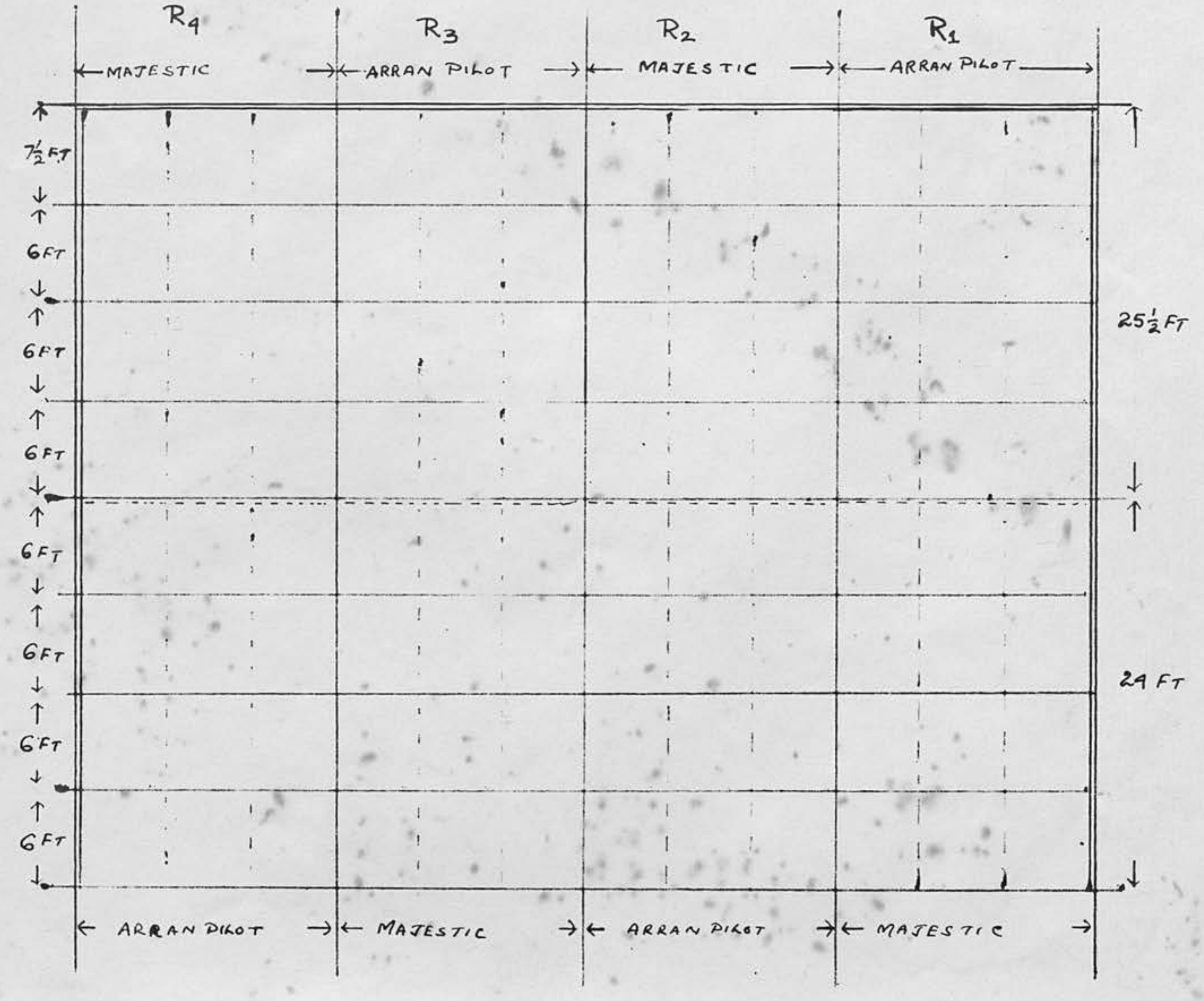


Fig.2 LAY OUT OF THE EXPERIMENT 2

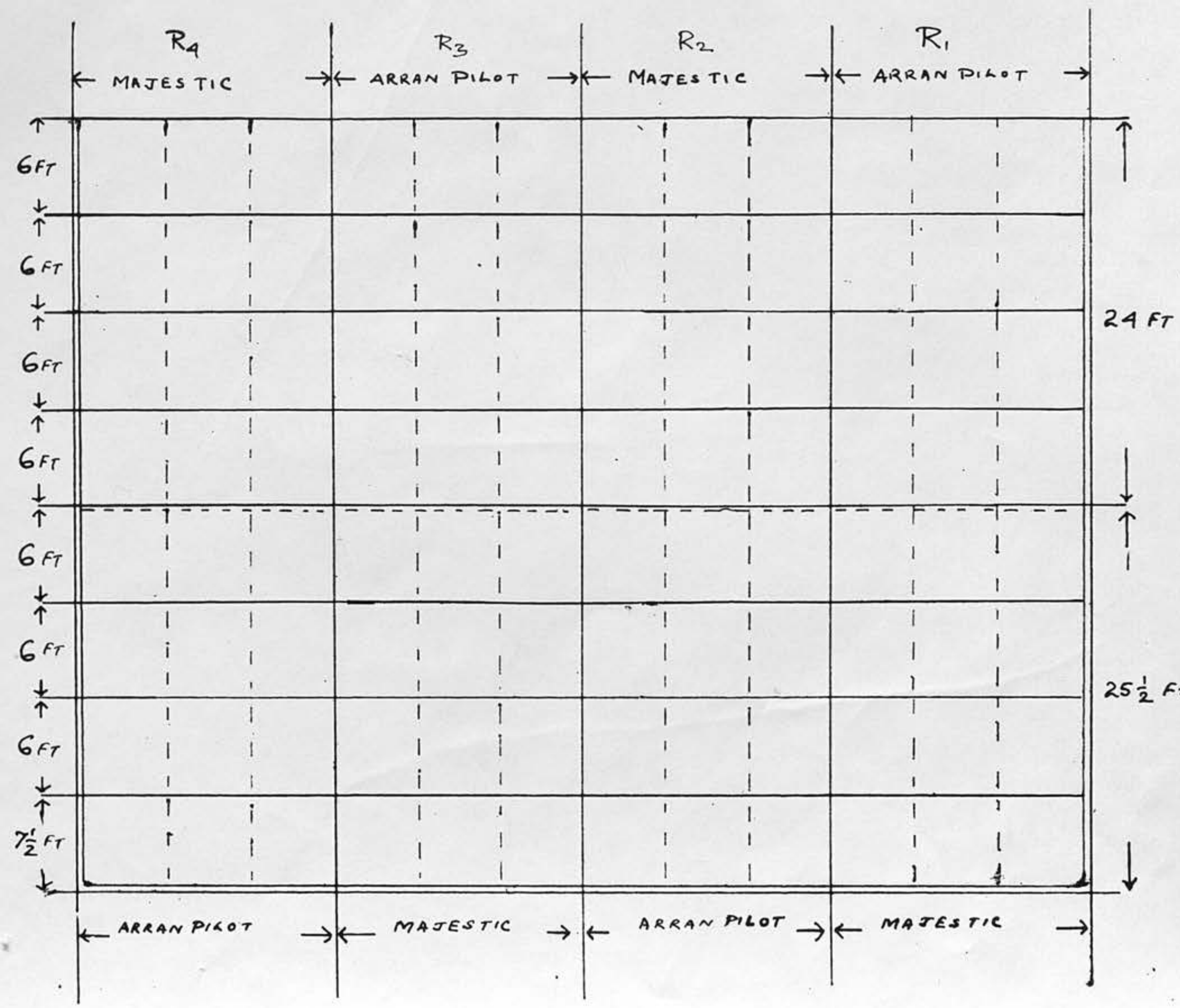
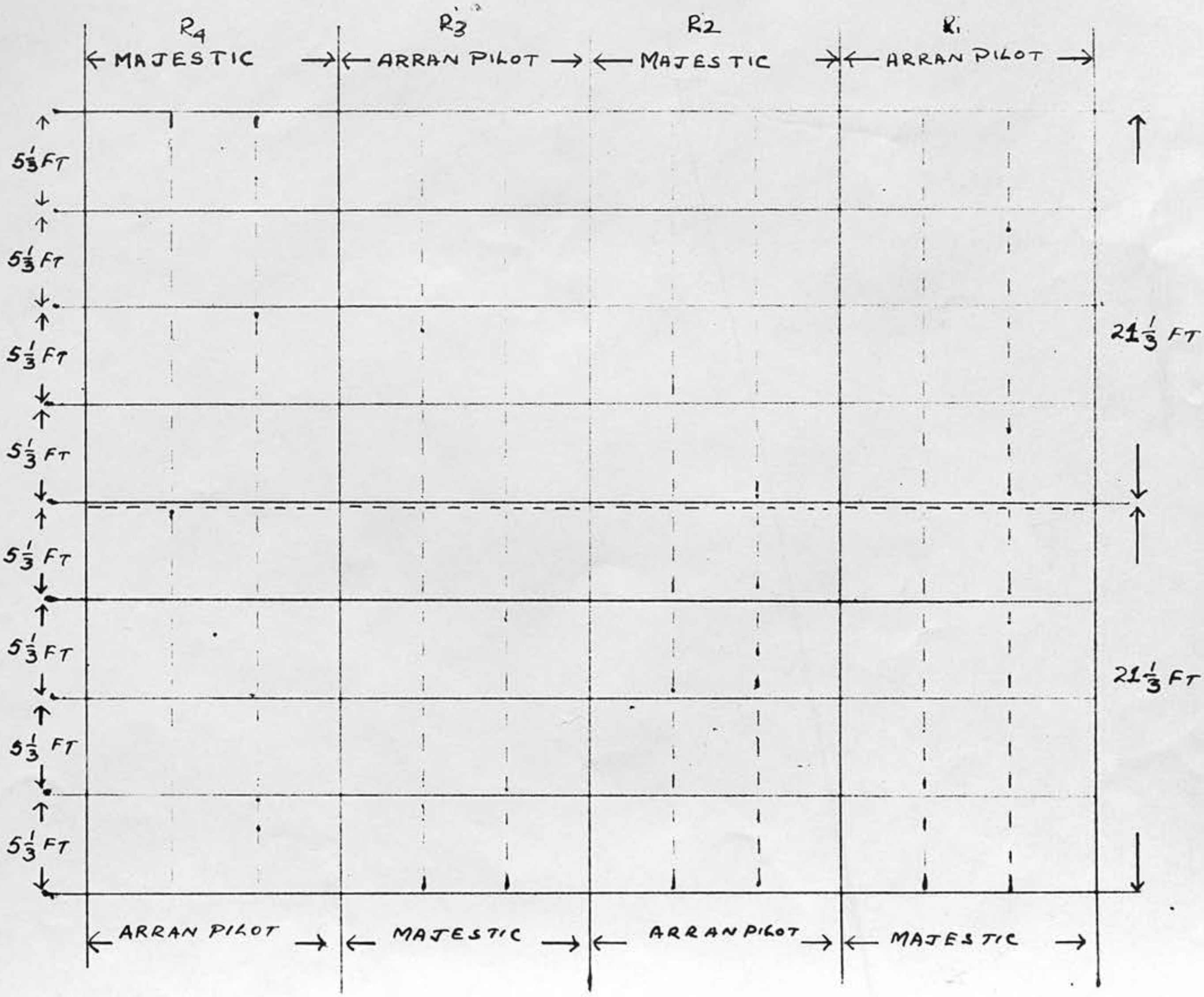


Fig.3 LAY OUT OF THE EXPERIMENT 3



maturity and observations were discontinued after 55 days. As all plants were free from Leaf Roll disease until 55 days after planting, the effect of virus disease on the rate of plant emergence has been ignored. During the period of observation rainfall was below average with near average temperatures and hours of sunshine were high (Appendix 2).

Observations and Collection of Data

(a) Observations During Storage Period

Experiment 1

(i) Number of sprouts per tuber at the beginning and end of the sprouting period in light, taking into account the number of sprouts per eye and the number of sprouted eyes per tuber.

(ii) Lengths of the longest sprout per tuber at intervals of four weeks during the sprouting period.

Experiment 2

(i) Number of sprouts per tuber at the end of the sprouting period in darkness, taking into account the number of sprouts per eye and sprouted eyes per tuber.

(ii) Lengths of sprouts (1 mm. and above) at the times of starting sprouting in darkness and after an interval of four weeks.

(iii) Fresh weight of tubers and sprouts at the end of sprouting in darkness.

Experiment 3

(i) Number of sprouts per tuber at the end of the sprouting period in light or darkness, taking into account the number of sprouts per eye and sprouted eyes per tuber.

(ii) Lengths of the longest sprout per tuber at the end of the sprouting period.

(b) Field Observation

Assessments of rate of emergence for various treatments were made from plant counts taken twice per week following planting. As soon as the sprouts broke through the ground with one expanded leaf they were counted.

Statistical Analysis and Method of the Presentation of Data

The number of sprouts per eye, sprouted eyes, sprouts per tuber and sprout weight as a percentage of the final weight of the tuber (as noted at the end of the sprouting period in light or darkness) were analysed statistically. In these analyses there is one estimate of error applicable to effect of variety, treatment and interaction of treatment and variety. For the rate of the plant emergence there are two estimates of error applicable to (a) effect of variety and (b) effect of treatment and interaction of treatment and variety. For the purpose of analysis of the rate of plant emergence, the data has been considered on the basis of the "Germination Rate Index". This was formulated by Bartlett (1937) as a measure of the rate of emergence, as follows:-

$$\text{"Germination Rate Index"} = \frac{S}{N \times F}$$

where S = Sum of the number of plants recorded at each counting date

N = Number of counting dates

F = Final number of plants.

Thus the index figure is higher with faster rates of emergence.

The other information is recorded in the form of a two way table on the basis of the statistical analysis with the appropriate standard error. The difference is considered significant whenever the difference is greater than $\sqrt{2}$ x S.E x t (least significant difference) [Fisher and Yates 1949].

Longest lengths of sprouts and rates of sprout growth have been expressed as the mean of 12 tubers.

Experiment 1. Effect of varying the period of storage of seed tubers with T.C.N.B. or at low temperature on subsequent sprouting in light and plant emergence in the field.

RESULTS

A. Observations During Storage Period

(i) Number of Sprouts per Tuber

It may be noted that some variation in sprouting condition was observed at the beginning of the sprouting period for the various storage treatments as is shown in Appendix 3. Arran Pilot showed bud activity during preliminary periods of storage for 57 days or more with T.C.N.B. or at low temperature. On the other hand, Majestic tubers remained apparently dormant in all storage treatments prior to sprouting, with the exception of the longest period (141 days) of storage at low temperature.

The results for the numbers of sprouts per tuber recorded at the end of the sprouting period (17th April) are summarised in Table 3. From the analysis of variance of the data (Appendix 4) the number of sprouts formed was found to vary with variety, storage treatment and the interactions between these two factors.

(a) Variety. The number of sprouts per tuber produced in Arran Pilot, averaged for all storage treatments, was greater than that in Majestic but the difference was only slight and can be traced largely to the greater

TABLE 3

Effect of varying periods of low temperature ($40^{o}F$) storage and of T.C.N.B. treatment on the number of sprouts per tuber at the end of the sprouting period in light (17th April)

Tr. No.	Storage Period from 19th October and Storage Treatments	Date of Sprouting	Number of Sprouts per tuber at the end of the Sprouting Period		
			Arran Pilot	Majestic	Mean
1.	Sprouted throughout in light	22.10.59	6.92	9.00	7.96
2.	31 days with T.C.N.B.	19.11.59	8.25	10.25	9.25
3.	31 days at $40^{o}F$	"	10.58	10.33	10.45
4.	57 days with T.C.N.B.	15.12.59	11.75	10.58	11.17
5.	57 days at $40^{o}F$	"	11.08	8.67	9.87
6.	85 days with T.C.N.B.	12. 1.60	13.33	9.58	11.46
7.	85 days at $40^{o}F$	"	12.67	13.83	13.25
8.	113 days with T.C.N.B.	9. 2.60	17.50	13.75	15.62
9.	113 days at $40^{o}F$	"	14.67	14.00	14.33
10.	141 days with T.C.N.B.	8. 3.60	24.17	13.50	18.83
11.	141 days at $40^{o}F$	"	14.75	13.08	13.92
12.	141 days without T.C.N.B. and then desprouted and sprouted in light	8. 3.60	10.25	11.17	10.71
	Mean		12.99	11.47	

S.E. of Variety ± 0.30 S.E. of Treatment ± 0.74
S.E. of Treatment x Variety ± 1.04

effect of the prolonged T.C.N.B. treatments (113 and 141 days) on the early variety (Table 3).

(b) Treatment. Tubers sprouted from the beginning of the storage period (October) formed significantly fewer sprouts than the average of all other treatments, where a delay in sprouting was involved (Table 4). Moreover, the

TABLE 4

Number of sprouts per tuber at the end of the sprouting period for continuous and delayed sprouting treatments

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted throughout in light (Tr. 1)	6.92	9.00	7.96
Delayed sprouting (Tr. 2-12)	13.54	11.70	12.62
Difference	-6.62	-2.70	-4.66
		±1.08	+0.77

sprout numbers tended to increase with the extent of the delay (Table 3). This trend was observed in both varieties, but was more marked in Arran Pilot. This again can be related to the effect of prolonged storage with T.C.N.B. on this variety.

The difference in response of varieties to the storage treatment with T.C.N.B. compared with that at low temperature without T.C.N.B. is shown in Table 5.

In Arran Pilot delay in sprouting resulted in a progressive increase in the number of sprouts per tuber from both T.C.N.B. treatment and low temperature storage, but the increase in the number of sprouts per tuber associated with delay in sprouting was more marked with the T.C.N.B. treatment. In fact tubers stored at low temperature until February and March did not form significantly greater numbers of sprouts than those sprouted in January, whereas with T.C.N.B. treatment further marked increases were evident from the longer periods of storage until February and March. Tubers stored with T.C.N.B. before sprouting formed on average more sprouts per tuber than those stored at low temperature and increases from the T.C.N.B. treatments were significant when sprouting was done during February and March (Table 5).

In Majestic the number of sprouts per tuber developed after sprouting in light was increased following previous storage until February or March with T.C.N.B. or at low temperature compared with the earlier sprouting treatments but no significant difference in effect between the two storage conditions was found (Table 5).

Tubers subjected to late desprouting before sprouting in light tended to produce more sprouts at the end of the sprouting period than those sprouted throughout the storage period but this effect was only significant in Arran Pilot (Table 3). The desprouting treatment gave

TABLE 5

Varietal difference in sprout numbers

Period of Storage before Sprouting in Light	Arran Pilot			Majestic		
	With T.C.N.B.	At 40°F i.e. No T.C.N.B.	Mean	With T.C.N.B.	At 40°F i.e. No T.C.N.B.	Mean
31 days, i.e. sprouted on 19.11.59	8.25	10.58	9.41	10.25	10.33	10.29
57 days, i.e. sprouted on 15.12.59	11.75	11.08	11.41	10.58	8.67	9.62
85 days, i.e. sprouted on 12.1.60	13.33	12.67	13.00	9.58	13.83	11.70
113 days i.e. sprouted on 9.2.60	17.50	14.67	16.08	13.75	14.00	13.87
141 days i.e. sprouted on 8.3.60	24.17	14.75	19.46	13.50	13.08	13.29
Mean	15.00	12.75		11.53	11.98	

S.E. of Variety x Treatment with T.C.N.B. and no T.C.N.B. (40°F) ± 0.47
S.E. of Variety x Time of Sprouting ± 0.74
S.E. of Variety x Time of Sprouting x Treatment with T.C.N.B. and no T.C.N.B. ± 1.04

fewer sprouts than the average of sprouting treatments where tubers had been previously stored with T.C.N.B. or at low temperature (Table 6) but the differences were only

TABLE 6

Number of sprouts per tuber at the end of the sprouting period for desprouting and for delayed sprouting treatments

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted in light after desprouting on 8.3.60 (Tr. 12)	10.25	11.17	10.71
Sprouted in light at intervals of four weeks from 19.11.59 to 8.3.60 without desprouting (Tr. 2-11)	13.87	11.76	12.82
Difference	-3.62	-0.59	-2.11
	±1.09		±0.77

significant in comparison with the late sprouting treatments in Arran Pilot, i.e. 113 and 141 days with T.C.N.B. or at low temperature (Table 3).

It may be noted that the nature of the desprouting treatment differed in the two varieties. In Majestic only a few sprouts were just visible (< 1 mm.) at the time of desprouting and were rubbed off whereas in Arran Pilot growth was advanced (longest sprout length 195 mm.) when sprouts were removed (Appendix 3).

In order to assess to what extent variations in the number of sprouts per tuber were related to changes in the number of eyes which produced sprouts or in the number of sprouts developed from eyes, the number of sprouted eyes per tuber and the mean number of sprouts per eye have been taken into account.

(ii) Number of Sprouted Eyes per Tuber

The effect of different treatments on the number of sprouted eyes per tuber, at the end of the sprouting period (17th April) is summarised in Table 7 and the analysis of variance of the data is shown in Appendix 6.

(a) Variety. Arran Pilot, averaged for all treatments, showed a greater number of sprouted eyes per tuber than Majestic, although it can be seen from Table 7 that this varietal difference relates more particularly to treatments where sprouting time was delayed and was only slight.

(b) Treatment. In both varieties tubers sprouted from the beginning of the storage period gave a slightly smaller number of sprouted eyes per tuber than that from the average of delayed sprouting treatments (Table 8). The increase from delayed sprouting was, however, only consistent with the later times of sprouting, i.e. 113 or 141 days at low temperature or T.C.N.B. treatment (Table 7).

In considering the effect of delay in the time of sprouting after varying periods of storage with T.C.N.B.

TABLE 7

Effect of varying periods of low temperature (40°F) storage and of T.C.N.B. treatment on the number of sprouted eyes per tuber at the end of the sprouting period in light (17th April)

Tr. No.	Storage Period from 19th October and Storage Treatments	Date of Sprouting	Number of Sprouted Eyes per Tuber at the end of the Sprouting Period		
			Arran Pilot	Majestic	Mean
1.	Sprouted throughout in light	22.10.59	6.67	7.33	7.00
2.	31 days with T.C.N.B.	19.11.59	6.67	7.92	7.29
3.	31 days at 40°F	"	8.33	7.58	7.96
4.	57 days with T.C.N.B.	15.12.59	6.67	7.42	7.04
5.	57 days at 40°F	"	7.75	6.92	7.33
6.	85 days with T.C.N.B.	12. 1.60	6.92	6.50	6.71
7.	85 days at 40°F	"	8.75	8.17	8.46
8.	113 days with T.C.N.B.	9. 2.60	8.58	8.25	8.41
9.	113 days at 40°F	"	9.25	8.75	9.00
10.	141 days with T.C.N.B.	8. 3.60	9.33	7.42	8.37
11.	141 days at 40°F	"	8.92	7.83	8.37
12.	141 days without T.C.N.B. and then desprouted and sprouted in light	8. 3.60	8.75	6.83	7.79
	Mean		8.05	7.58	

S.E. of Variety ±0.14
S.E. of Treatment ±0.33
S.E. of Treatment x Variety ±0.48

TABLE 8

Number of sprouted eyes per tuber at the end of the sprouting period for continuous and delayed sprouting treatments

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted throughout in light (Tr. 1)	6.67	7.33	7.00
Delayed sprouting (Tr. 2-12)	8.17	7.60	7.88
Difference	-1.50	-0.23	0.88
	±0.49		±0.35

TABLE 9

Number of sprouted eyes per tuber at the end of the sprouting period, stored with T.C.N.B. and at 40°F for varying periods before sprouting in light

Period of Storage before Sprouting in Light	With T.C.N.B	At 40°F i.e. No T.C.N.B.	Mean
31 days, i.e. sprouted on 19.11.59	7.29	7.96	7.62
57 days, i.e. sprouted on 15.12.59	7.04	7.33	7.19
85 days i.e. sprouted on 12. 1.60	6.71	8.46	7.58
113 days i.e. sprouted on 9. 2.60	8.42	9.00	8.71
141 days i.e. sprouted on 8. 3.60	8.37	8.37	8.37
Mean	7.57	8.22	

S.E. of Treatment with T.C.N.B. and no T.C.N.B. ±0.11

S.E. of Time of Sprouting ±0.24

S.E. of Time of Sprouting x Treatment with T.C.N.B. and no T.C.N.B. ± 0.33

or at low temperature, it was found that with the average of both varieties tubers sprouted during February and March gave rise to a significantly greater number of sprouted eyes per tuber than those sprouted during November and December (Table 9). This effect applied to both storage methods but in comparing T.C.N.B. with low temperature storage there was a tendency for fewer eyes to develop sprouts with the former treatment (Table 9).

The removal of sprouts before sprouting had no significant effect on the number of sprouted eyes compared with the average of other storage treatments with T.C.N.B. or at low temperature (Table 10) but there was some

TABLE 10

Number of sprouted eyes per tuber at the end of the sprouting period for desprouting and for delayed sprouting treatments

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted in light after de-sprouting on 8.3.60 (Tr.12)	8.75	6.83	7.79
Sprouted in light at intervals of four weeks from 19.11.59 to 8.3.60 without desprouting (Tr. 2-11)	8.12	7.67	7.89
Difference	+0.63	-0.84	-0.10
	±0.50		±0.35

evidence of a varietal interaction (Appendix 6). Arran Pilot tended to give a greater number of sprouted eyes per tuber after desprouting than Majestic and this might be related to the fact that little sprout development had occurred at the time of desprouting in the latter variety (Appendix 3).

(iii) Number of Sprouts per Eye

The number of sprouts per eye at the end of the sprouting period (17th April) was found to vary with variety, storage treatments and the interaction between the two factors (Appendix 8). The number of sprouts per eye recorded at the end of the sprouting period in light from the different storage treatments is shown in Table 11.

(a) Variety. Arran Pilot produced on average a greater number of sprouts per eye than Majestic but the increase can be attributed to the effect of prolonged storage with T.C.N.B. (Table 11).

(b) Treatment. Tubers of both varieties sprouted throughout showed a smaller number of sprouts per eye than all other treatments, where a delay in sprouting was involved, and this effect appeared more marked in Arran Pilot (Table 12). The difference in varietal response was significant (Appendix 8) but is again related to the effect of prolonged storage with T.C.N.B. on Arran Pilot (Table 11).

In comparing the effects of different times of sprouting after storage for varying periods at low

TABLE 11

Effect of varying periods of low temperature (40^oF) storage and of T.C.N.B. treatment on the number of sprouts per eye at the end of the sprouting period in light (17th April)

Tr. No.	Storage Period from 19th October and Storage Treatments	Date of Sprouting	Number of Sprouts per eye at the end of the Sprouting Period		
			Arran Pilot	Majestic	Mean
1.	Sprouted throughout in light	22.10.59	1.04	1.20	1.12
2.	31 days with T.C.N.B.	19.11.59	1.24	1.29	1.26
3.	31 days at 40^oF	"	1.27	1.36	1.32
4.	57 days with T.C.N.B.	15.12.59	1.75	1.38	1.57
5.	57 days at 40^oF	"	1.43	1.24	1.34
6.	85 days with T.C.N.B.	12. 1.60	1.98	1.46	1.72
7.	85 days at 40^oF	"	1.44	1.66	1.55
8.	113 days with T.C.N.B.	9. 2.60	2.05	1.65	1.85
9.	113 days at 40^oF	"	1.58	1.63	1.61
10.	141 days with T.C.N.B.	8. 3.60	2.60	1.85	2.22
11.	141 days at 40^oF	"	1.71	1.66	1.68
12.	141 days without T.C.N.B. and then desprouted and sprouted in light	8. 3.60	1.16	1.65	1.41
	Mean		1.60	1.50	

S.E. of Variety ± 0.02

S.E. of Treatment ± 0.06

S.E. of Treatment x Variety ± 0.29

TABLE 12

Number of sprouts per eye at the end of the sprouting period for continuous and delayed sprouting treatments

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted throughout in light (Tr. 1)	1.04	1.20	1.12
Delayed sprouting (Tr. 2-12)	1.65	1.53	1.59
Difference	-0.61	-0.33	-0.47
	±0.09		±0.07

temperature or with T.C.N.B. it was found that in Arran Pilot delay in sprouting caused an increase in the number of sprouts per eye, but this increase was accentuated with T.C.N.B. treatment (Table 13). In Arran Pilot, tubers previously stored with T.C.N.B. gave rise to a significantly greater number of sprouts per eye after sprouting in light than those stored at low temperature without T.C.N.B. and this sprouting behaviour associated with T.C.N.B. was more apparent when the period of storage was prolonged (Table 13). The increase in the number of sprouts per eye associated with delay in sprouting was also found in Majestic, but treatment with T.C.N.B. did not result in a greater number of sprouts per eye than previous storage at low temperature without T.C.N.B. (Table 13).

The number of sprouts per eye after desprouting was

TABLE 13

Varietal difference in sprouts per eye

Period of Storage before Sprouting in Light	Arran Pilot			Majestic		
	With T.C.N.B	At $40^{o}F$ i.e. No T.C.N.B.	Mean	With T.C.N.B.	At $40^{o}F$ i.e. No T.C.N.B.	Mean
31 days, i.e. sprouted on 19.11.59	1.24	1.27	1.25	1.29	1.36	1.32
57 days, i.e. sprouted on 15.12.59	1.75	1.43	1.59	1.38	1.24	1.31
85 days, i.e. sprouted on 12.1.60	1.98	1.44	1.71	1.46	1.66	1.56
113 days i.e. sprouted on 9.2.60	2.05	1.58	1.81	1.65	1.63	1.64
141 days i.e. sprouted on 8.3.60	2.60	1.71	2.15	1.85	1.66	1.75
Mean	1.92	1.48		1.53	1.51	

S.E. of Variety x Treatment with T.C.N.B. and no T.C.N.B. ± 0.042

S.E. of Variety x Time of Sprouting ± 0.064

S.E. of Variety x Time of Sprouting x Treatment with T.C.N.B. and no T.C.N.B. ± 0.29

greater than that where tubers were sprouted throughout the storage period but the difference in effect between the two treatments was only significant in Majestic (Table 11). Compared with other storage treatments, tubers subjected to desprouting tended to give fewer sprouts per eye in Arran Pilot but not in Majestic (Table 14). Thus in Arran Pilot

TABLE 14

Number of sprouts per eye at the end of the sprouting period for desprouting and delayed sprouting treatments

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted in light after desprouting on 8.3.60 (Tr. 12)	1.16	1.65	1.41
Sprouted in light at intervals of four weeks from 19.11.59 to 8.3.60 without desprouting (Tr. 2-11)	1.70	1.52	1.61
Difference	-0.54	+0.13	-0.20
	±0.09		±0.07

numbers of sprouts formed per eye were slightly greater after storage periods of 113 and 141 days at low temperature compared with desprouting, and was notably greater from storage periods of 85, 113 and 141 days with T.C.N.B. (Table 11).

(iv) Sprout Length

The frequency distribution of sprouts in different length categories for the various treatments at the end of the sprouting period is given in Appendix 10.

In Arran Pilot the increase in sprout numbers following delay in time of sprouting gave rise to more sprouts in the 1-10 mm. and 10-20 mm. size classes but fewer sprouts developed over 30 mm. in comparison with earlier sprouting. The large increases in numbers following long periods of storage with T.C.N.B. referred to sprouts <10 mm. Sprout lengths in Majestic were generally shorter than in Arran Pilot. In Majestic increased numbers following delay in sprouting were found in the 1-10 mm. class and fewer sprouts above 10 mm. (Appendix 10).

The mean lengths of the dominant, i.e. the longest, sprout per tuber at various dates after different storage treatments are given in Appendix 11.

As would be expected, sprout length was generally greater in Arran Pilot than in Majestic and in both varieties the length was reduced with shorter periods of sprouting. There appeared to be no difference, however, between the effect of previous storage treatment with T.C.N.B. compared with that of low temperature storage on longest sprout length at the time of planting (Table 15).

Fig. 4 A and B show that in Arran Pilot the maximum rate of growth of the longest sprout occurred in the first

TABLE 15

Effect of varying periods of low temperature (40°F) storage and of T.C.N.B. treatment on the length of longest sprout

Tr. No.	Storage Period from 19th October and Storage Treatments	Date of Sprouting	Arran Pilot	Majestic
1.	Sprouted throughout in light	22.10.59	37.25	16.83
2.	31 days with T.C.N.B.	19.11.59	31.67	15.00
3.	31 days at 40°F	"	35.50	17.33
4.	57 days with T.C.N.B.	15.12.59	29.83	17.83
5.	57 days at 40°F	"	26.00	16.33
6.	85 days with T.C.N.B.	12. 1.60	25.08	12.92
7.	85 days at 40°F	"	21.42	13.25
8.	113 days with T.C.N.B.	9. 2.60	17.00	8.50
9.	113 days at 40°F	"	19.83	10.17
10.	141 days with T.C.N.B.	8. 3.60	19.91	9.33
11.	141 days at 40°F	"	19.83	9.33
12.	141 days without T.C.N.B. and then desprouted and sprouted in light	8. 3.60	22.58	9.83

four weeks of the sprouting period, with the exception of the earliest sprouting treatment where maximum growth rate was found during the second four week period. In Majestic

Fig.4 EFFECT OF VARYING PERIODS OF LOW TEMPERATURE(40°F) STORAGE AND OF T.C.N.B. TREATMENT ON THE GROWTH OF LONGEST SPROUT OF ARRAN PILOT IN LIGHT (AVG.12 TUBERS)

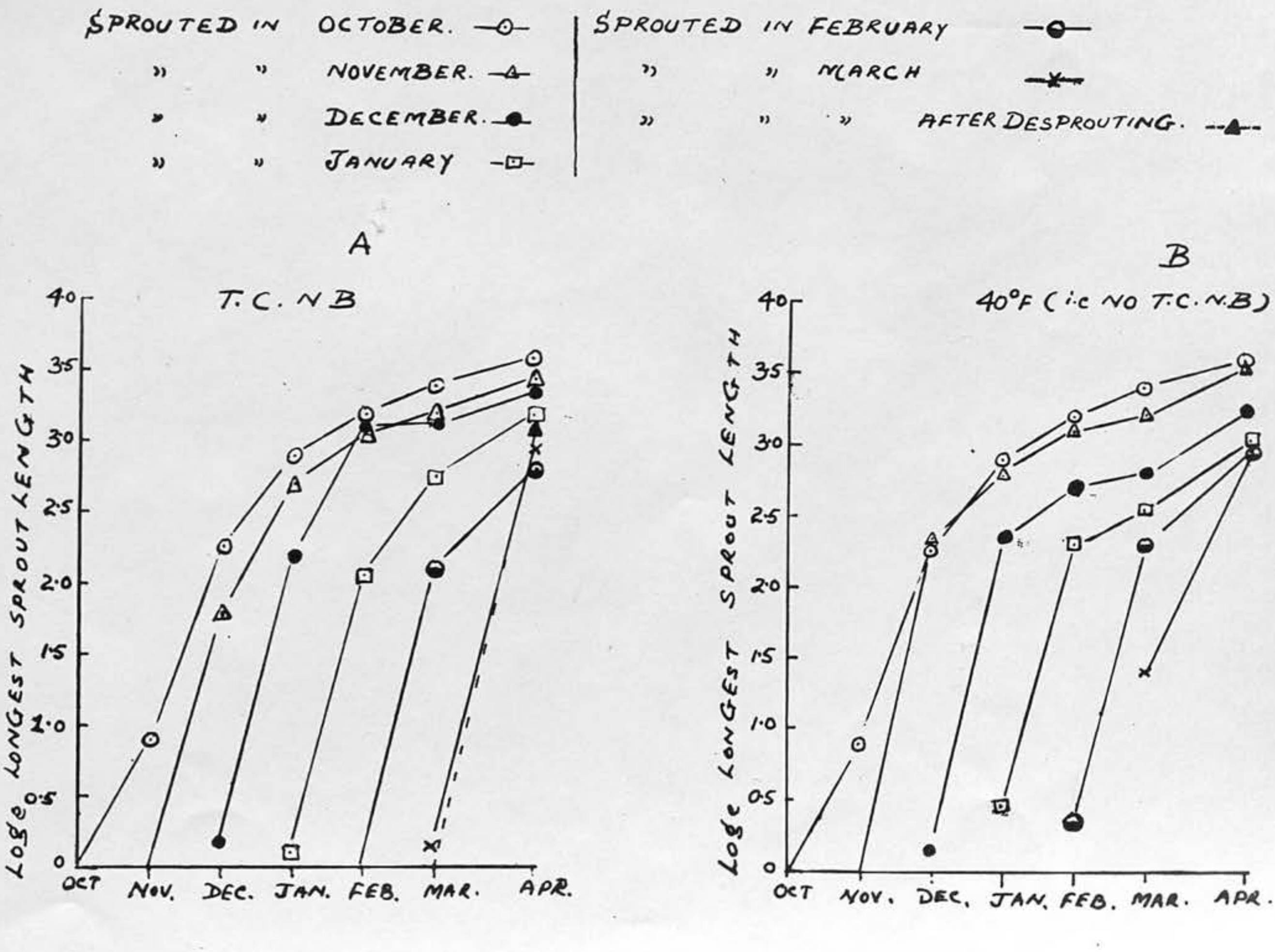
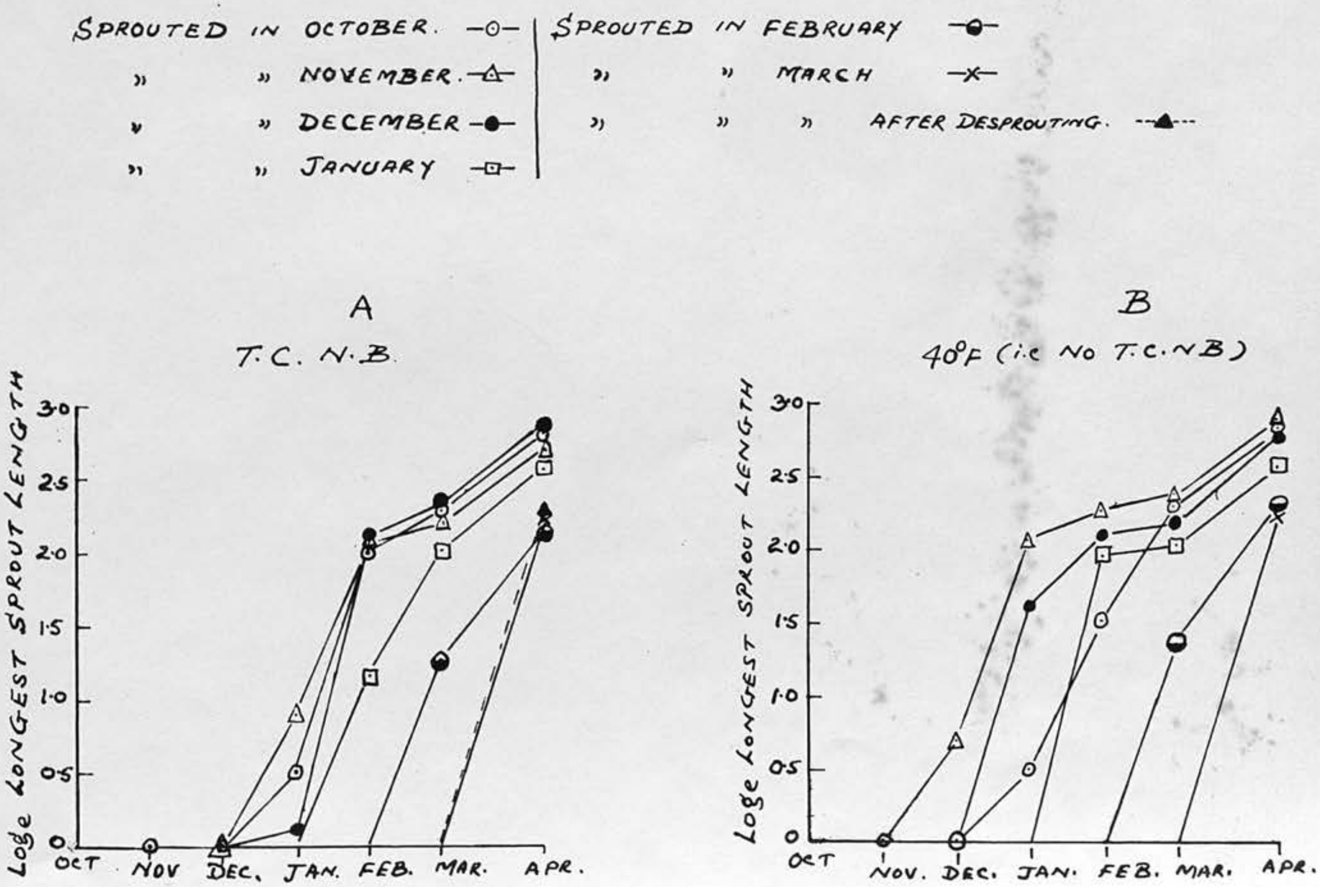


Fig.5 EFFECT OF VARYING PERIODS OF LOW TEMPERATURE (40°F) STORAGE AND OF T.C.N.B. TREATMENT ON THE GROWTH OF LONGEST SPROUT OF MAJESTIC IN LIGHT (AVG.12 TUBERS)



(Fig. 5 A and B) with tubers sprouted in October (i.e. the earliest sprouting treatment) maximum growth rate was not attained until the third four week period after sprouting. Tubers sprouted in November showed their maximum growth rate in the third period and second period after previous storage with T.C.N.B. and at low temperature respectively. When sprouted in December, tubers previously stored with T.C.N.B. gave their maximum growth rate in the second four week period, while those stored at low temperature gave their maximum growth rate in the first four week period after sprouting was commenced, as did all later sprouting treatments. These results accord with the concept of a longer period of dormancy in Majestic than in Arran Pilot.

In comparing the effect of storage with T.C.N.B. with storage at low temperature the growth rate of Arran Pilot was somewhat slower during the first four week period for T.C.N.B. treatments but later growth made up this difference, as is illustrated by the more gradual but less rapid flattening out of the growth curves (Fig. 4 A and B and Appendix 11).

In Majestic also, growth tended to be slower following T.C.N.B. treatment, but again later growth appeared to reduce any difference by the end of the sprouting period (Fig. 5 A and B and Appendix 11). Low temperature treatment until November tended to stimulate early sprouting in Majestic. It can be seen from Fig. 5 B that tubers stored at low temperature and sprouted in November formed sprouts during December, whereas those sprouted in October showed development of sprouts during January. In fact, despite the longer period of sprouting in light, tubers sprouted in October did not show greater length of longest sprout at the end of the sprouting period than those held at low temperature or with T.C.N.B. until November and December (Table 15). This behaviour of sprout growth in Majestic can be related to the dormancy of the tuber and thus tubers sprouted from the beginning (October) failed to show early growth of sprouts and some time was required to complete the period of rest or dormancy.

The growth rate of the longest sprout during the first four week period of sprouting tended to be similar for the different times of sprouting despite the fact that the number of sprouts increased as the time of sprouting was delayed, when there was a greater competition for the available nutrition for sprout growth (Fig. 4 A and B; 5 A and B). There was, therefore, evidence that the vigour of sprout growth increased with age. Krijthe (1958) reported that from the time of lifting onwards to a certain stage of life the germinating power of tubers (i.e. weight of sprouts produced during a fixed period of four weeks under a constant temperature at 20°C by tubers stored previously at 2°C) increases with the age of the tuber.

Removal of sprouts before sprouting in light during March did not adversely affect growth of the longest sprout. In fact, irrespective of variety, the length of the longest

TABLE 16

Effect of varying periods of low temperature (40^oF) storage and of T.C.N.B. treatment on the average number of days to plant emergence

Tr. No.	Storage Period from 19th October and Storage Treatments	Date of Sprouting	Arran Pilot	Majestic
1.	Sprouted throughout in light	22.10.59	20.42	20.25
2.	31 days with T.C.N.B.	19.11.59	18.42	18.67
3.	31 days at 40^oF	"	19.83	18.58
4.	57 days with T.C.N.B.	15.12.59	19.33	19.75
5.	57 days at 40^oF	"	18.92	17.67
6.	85 days with T.C.N.B.	12. 1.60	19.58	19.33
7.	85 days at 40^oF	"	17.33	19.17
8.	113 days with T.C.N.B.	9. 2.60	19.42	20.50
9.	113 days at 40^oF	"	19.83	20.33
10.	141 days with T.C.N.B.	8. 3.60	22.42	21.50
11.	141 days at 40^oF	"	22.17	20.83
12.	141 days without T.C.N.B. and then desprouted and sprouted in light	8. 3.60	20.25	22.17

sprouts (Table 15) and their rate of growth (Appendix 11) in tubers subjected to desprouting before sprouting in light was greater than those sprouted at the same time with sprouts intact.

B. Rate of Plant Emergence

The percentage plant emergence at successive dates after planting and the average number of days to emergence are shown in Appendix 12 and Table 16 respectively.

The mean "Germination Rate Index" of different storage treatments and the analysis of variance are shown in Table 17 and Appendix 13 respectively.

From the analysis of variance for variety and storage treatment the only significant effect on emergence rate related to prolonged storage with T.C.N.B. or at low temperature (Appendix 13). It can be seen from Table 18 that tubers held for 141 days before sprouting were significantly slower in emergence than tubers from all other treatments, but it may be noted that the delay in emergence is only slight (Table 16).

Although sprout length was longer on tubers of Arran Pilot than those of Majestic at the time of planting no significant difference in emergence rate (Average of storage treatment) between the two varieties was found (Table 17 and Appendix 12). Thus it appears that while Arran Pilot showed a more vigorous growth rate of sprouts during the storage and sprouting period, this increased vigour was not sustained after the tubers were planted in the field.

In considering the relationship between sprout length and emergence rate, however, a significant negative correlation between the number of days required to emerge

TABLE 17

Effect of varying periods of low temperature (40°F) storage and of T.C.N.B. treatment on the "Germination Rate Index"

Tr. No.	Storage Period from 19th October and Storage Treatments	Date of Sprouting	Germination Rate Index		
			Arran Pilot	Majestic	Mean
1.	Sprouted throughout in light	22.10.59	0.750	0.764	0.757
2.	31 days with T.C.N.B.	19.11.59	0.847	0.833	0.840
3.	31 days at 40°F	"	0.778	0.847	0.812
4.	57 days with T.C.N.B.	15.12.59	0.805	0.791	0.798
5.	57 days at 40°F	"	0.833	0.889	0.861
6.	85 days with T.C.N.B.	12. 1.60	0.792	0.805	0.799
7.	85 days at 40°F	"	0.903	0.819	0.861
8.	113 days with T.C.N.B.	9. 2.60	0.806	0.750	0.778
9.	113 days at 40°F	"	0.778	0.764	0.771
10.	141 days with T.C.N.B.	8. 3.60	0.653	0.708	0.680
11.	141 days at 40°F	"	0.667	0.736	0.701
12.	141 days without T.C.N.B. and then desprouted and sprouted in light	8. 3.60	0.764	0.667	0.715
	Mean		0.781	0.781	

S.E. of Variety ±0.011

S.E. of Treatment ±0.040

S.E. of Treatment x Variety ±0.057

Fig.6 RELATIONSHIP BETWEEN THE LENGTH OF LONGEST PER TUBER AND THE NUMBER OF DAYS TO PLANT EMERGENCE (EACH POINT REPRESENTING A TREATMENT MEAN)

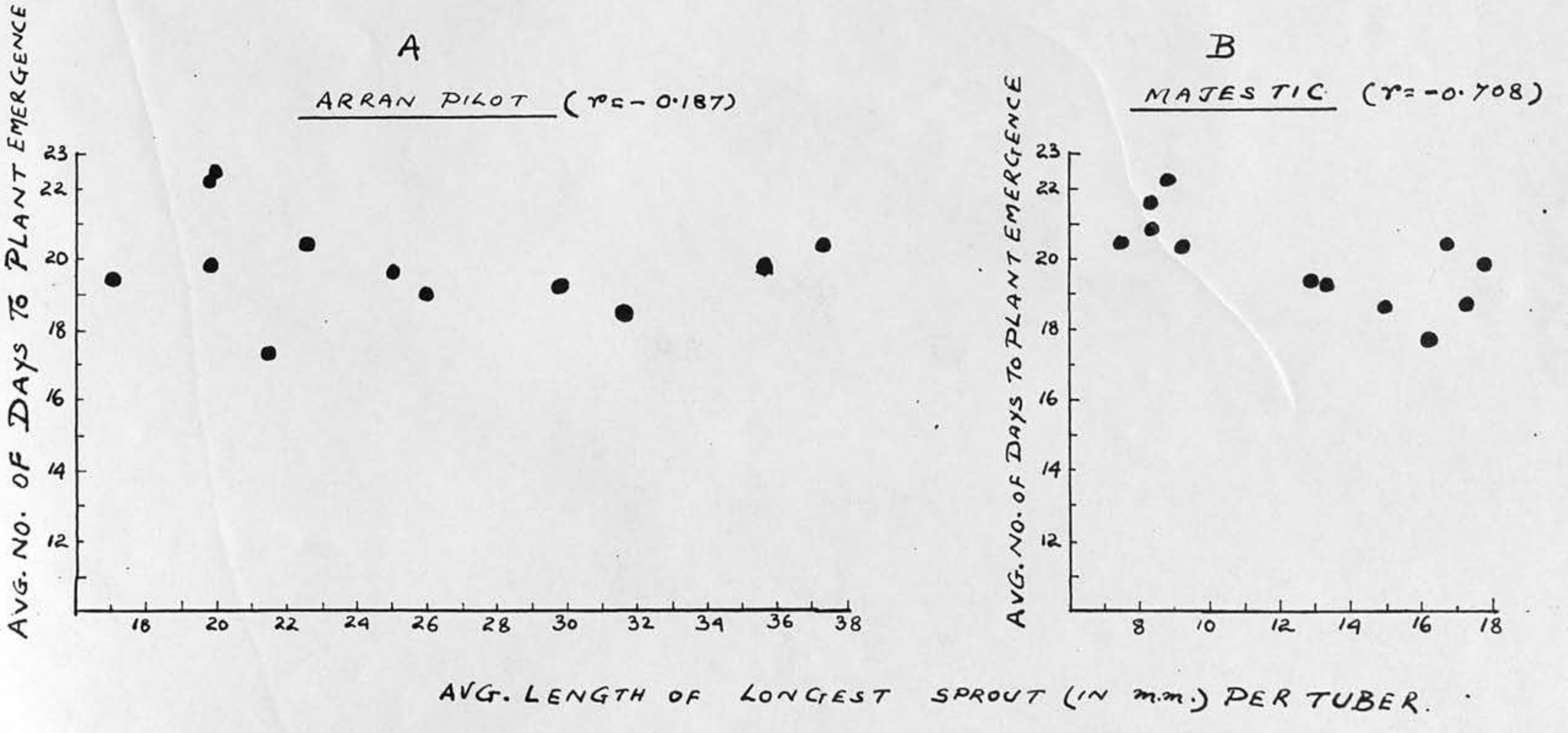


TABLE 18

Effect of period of storage or time of sprouting in light on "Germination Rate Index" (Average of variety and treatment with T.C.N.B.)

Period of Storage before Sprouting in Light	Germination Rate Index
31 days, i.e. sprouted in November	0.826
57 days, i.e. sprouted in December	0.830
85 days, i.e. sprouted in January	0.830
113 days, i.e. sprouted in February	0.774
141 days, i.e. sprouted in March	0.691

S.E. of Time of Sprouting ± 0.028

and the longest sprout length was found in Majestic ($r = -0.708$) [Fig. 6 B] where sprout length ranged from 9.33 mm. to 17.83 mm. (Table 15). In Arran Pilot the correlation was not significant ($r = -0.187$) [Fig. 6 A]. In this variety the length of the longest sprout ranged from 17.00 mm. to 37.25 mm. (Table 15) which would suggest that the length exceeded the limit above which further response might not be expected.

C. DISCUSSION

EXPERIMENT 1

Delaying the time of sprouting by prolonging the period of storage at low temperature with or without T.C.N.B. before exposing tubers to light at temperatures suitable for growth resulted in an increase in the number of sprouts per tuber. Larger numbers of sprouts per tuber associated with the delay in sprouting was partly due to the increased number of sprouted eyes per tuber and partly to the greater number of sprouts per eye. Many authors have observed that after passing through the rest period and under favourable conditions for sprout growth the tuber tends to produce a single sprout from the apical eye only with a suppression of sprout growth from the other eyes (Appleman 1925, Kawakami 1953). Where there is a delay in sprouting the number of sprouts produced increases with the age of the tuber (Kawakami 1953). It had also been shown by Bushnell (1929), Toosey (1959) and Hiele (1961) that with delay in time of sprouting following low temperature storage, the tuber exhibited a loss of apical dominance and thereby an increase in the degree of multiple sprouting. It seems that loss of apical dominance of tubers associated with delay in sprouting resulted in a greater number of eyes becoming active and also a larger number of buds within an eye giving rise to sprouts.

In the present observations, however, the earliest sprouting treatment did not give rise to complete apical dominance and in both varieties tubers sprouted from the end of October gave rise to more than one active sprout at the time of planting. This might indicate that at the start of the experiment tubers had already passed out of the one sprouting phase, although it was observed that in the early stages of sprouting only one sprout tended to become active and active growth from other eyes developed later. On the other hand, with later sprouting treatments several sprout buds tended to start activity at the same time. Bushnell (1929) did report that even with early sprouting of tubers there is a tendency for further eyes to develop sprouts with increase in the age of tubers where favourable growing conditions are maintained and this observation is in keeping with the results obtained.

Treatment with T.C.N.B. (Tetrachloronitrobenzene) during storage at low temperature also influenced the subsequent number of sprouts developed, notably in Arran Pilot for prolonged periods of storage. In Arran Pilot, tubers stored with T.C.N.B. before sprouting in light gave a greater number of sprouts per tuber than those stored without T.C.N.B. and this may be attributed to more sprouts per eye rather than sprouted eyes per tuber in the former case. Brown and Reavill (1954) showed that tubers stored with T.C.N.B. gave a larger number of sprouts per tuber than those stored without T.C.N.B. The authors further commented that in treated tubers at higher temperature (where bud activity would presumably tend to be greater) as many as fifteen sprouts developed at an eye, giving a "witches broom" appearance. In the present observation it was noted that Arran Pilot was in a more active sprouting condition even at low temperature than Majestic which might explain the response to T.C.N.B. being restricted to the former variety. Hiele (1961) also reported that growth regulating substances such as T.C.N.B. used for prolonging dormancy frequently increase the number of sprouts per tuber.

Although the initial growth rate of the longest sprout tended to be slower following T.C.N.B. treatment, later growth made up this difference and near the time of planting there appeared to be no difference between the effect of previous storage treatment with T.C.N.B. and that of low temperature storage without T.C.N.B. on the longest length of sprout. Brown and Reavill (1954) suggested that the effect of T.C.N.B. disappears when the active principle is removed from the treated tuber and the sprouts which have been retarded in growth by the dust will then begin to grow at the same rate as untreated sprouts.

The development of sprouts was related to variety; Arran Pilot, a vigorous sprouting variety, formed a larger number of sprouts notably with delayed sprouting treatments and also had a greater length of the longest sprout than Majestic, a slow sprouting variety. Arran Pilot is recognised as an early sprouting variety with a short dormant period whereas Majestic is slower in making active sprout growth. Thus it was found that in October sprouted tubers visible sprouting commenced earlier in the former variety. In Majestic, however, low temperature treatment for a short period (November) tended to stimulate subsequent sprout growth in light relative to that of exposure at growing temperature conditions from the beginning of the storage period. It seems that in Majestic, storage at low temperature for a short period followed by sprouting in light at higher temperature resulted in an interruption of dormancy earlier than sprouting in the light from the beginning of the storage period under a favourable temperature for growth. Fluctuating the temperature of storage or transferring from low to high temperature has been observed previously to result in a breaking of dormancy (Snell 1932, Schippers 1955).

While Arran Pilot showed a more vigorous growth rate of sprouts during the sprouting period than Majestic, this increased vigour was not sustained after the tubers were planted in the field and in fact no significant difference in emergence rate between the two varieties was found. In Majestic, the longest sprout length ranged from 9.33 mm. to 17.83 mm. at the time of planting and there was a significant negative correlation between the number of days required to emerge and longest sprout length whereas, in Arran Pilot, the correlation was not significant where the longest sprout ranged from 17.0 mm. to 37.25 mm. in length. This result suggests that the sprout length in the latter variety exceeded the limit above which further response in early plant emergence might be expected. These findings are in agreement with Headford (1960 and 1962) who showed that increase in sprout length up to 15 mm. caused a considerable reduction in the time of emergence and longer sprout lengths than this gave no further response. Headford (1962) further considered that King Edward (a main crop variety) produced plants above ground as early as Arran Pilot (an early variety) when the two varieties had the same sprout length.

In these experiments there was no advantage in sprouting earlier than February in Arran Pilot for early plant emergence, and sprouting in March delayed plant emergence. In Majestic, emergence was only significantly earlier when sprouting was started in December or November in comparison with the March sprouting treatment, indicating the advantage of a longer sprouting period in this variety. Owers (1960) suggested that the slow sprouting varieties such as Majestic and King Edward needed a longer period of sprouting for early plant emergence than a variety such as Arran Pilot which is noted for its rapidity of sprout growth. The results confirm that the time of sprouting of a particular variety should be based on its characteristic sprout growth rate: the greater the rate, the longer should the start of sprouting be delayed.

D. CONCLUSIONS

EXPERIMENT 1

In Experiment 1 studies were carried out on the effect of delaying sprouting by low temperature storage or T.C.N.B. treatment for varying periods before sprouting in light on subsequent sprout development and plant emergence in Arran Pilot and Majestic.

1. The number of sprouts per tuber developed at the end of the sprouting period (17th April) in light increased by prolonging the period of storage at low temperature with or without T.C.N.B. (Tetra-Chloronitrobenzene) before exposing tubers to light at a temperature suitable for growth.

2. Increase in sprout number associated with the delay in time of sprouting was partly due to the increase in the number of sprouted eyes and partly to the increase in the number of sprouts per eye.

3. Tubers of Arran Pilot stored over prolonged periods (October to February or March) and previously treated with T.C.N.B. during storage at low temperature resulted subsequently in a marked increase in numbers of sprouts over those stored without T.C.N.B. Greater numbers of sprouts per tuber associated with T.C.N.B. treatment were mainly due to a larger number of sprouts per eye. T.C.N.B. had no significant effect in the case of shorter periods of storage (October to November, December or January) in this

variety or in the case of Majestic irrespective of storage period.

4. The growth curve of the longest sprout on a tuber was a classic sigmoid. In Arran Pilot maximum rate of growth of the longest sprout occurred in general during the first four weeks of the sprouting period. In the case of Majestic when the sprouting was carried out during December or before, the maximum growth rate of the longest sprout was not attained until the second or third four week period after sprouting and in the later sprouting treatment (i.e. after December) maximum growth rate occurred during the first four weeks of the sprouting period.

5. Previous treatment with T.C.N.B. had no effect on the final growth of the longest sprout in light relative to no T.C.N.B. treatment.

6. There was no advantage in sprouting earlier than February in Arran Pilot for early plant emergence but delay in sprouting until March resulted in a slower rate of plant emergence compared with all earlier sprouting treatments. In Majestic, longer periods of sprouting as early as November or December resulted in earlier plant emergence in comparison with the March sprouting, indicating the advantage of a longer sprouting period in this variety. In fact, there was a significant negative correlation in Majestic between the number of days required to emerge and

the longest sprout length, whereas in Arran Pilot the correlation was not significant.

Experiment 2. Effect of varying the period of storage of seed tubers with T.C.N.B. or at low temperature (40°F) on subsequent sprouting in darkness and emergence in the field after desprouting before planting.

RESULTS

A. Observations During Storage Period

(i) Sprout Numbers per Tuber

The number of sprouts produced at the end of the sprouting period in darkness (23rd April) for the various treatments is given in Table 19 and the analysis of variance of the results in Appendix 18. Both variety and storage treatment and their interaction were found to have significant effects.

Tubers of Arran Pilot sprouted continuously in darkness from the beginning of the experiment produced fewer sprouts than comparable tubers of Majestic but formed more sprouts per tuber than Majestic in all cases where there was a delay in sprouting following previous storage with T.C.N.B. or at low temperature (Table 19). There was no significant difference in the number of sprouts per tuber after desprouting in March between varieties (Table 19). In Arran Pilot sprouting in October gave fewer sprouts per tuber than all other treatments, whereas no significant difference was found in Majestic comparing October sprouting with the average of all other treatments (Table 20). Moreover, previous storage with T.C.N.B. or at low temperature for periods ranging from 31 to 141 days gave more sprouts per

TABLE 19

Effect of varying periods of low temperature (40°F) storage and of T.C.N.B. treatment on the number of sprouts per tuber at the end of the sprouting period in darkness (23rd April)

Tr. No.	Storage Period from 19th October and Storage Treatments	Date of Sprouting	Number of Sprouts per tuber at the end of the Sprouting Period		
			Arran Pilot	Majestic	Mean
1.	Sprouted throughout in darkness	22.10.59	4.92	10.75	7.83
2.	31 days with T.C.N.B.	19.11.59	14.25	11.00	12.62
3.	31 days at 40°F	"	13.50	9.92	11.71
4.	57 days with T.C.N.B.	15.12.59	18.83	12.08	15.46
5.	57 days at 40°F	"	15.67	9.17	12.42
6.	85 days with T.C.N.B.	12. 1.60	15.83	12.83	14.33
7.	85 days at 40°F	"	14.75	11.67	13.21
8.	113 days with T.C.N.B.	9. 2.60	22.75	15.42	19.09
9.	113 days at 40°F	"	14.58	11.75	13.17
10.	141 days with T.C.N.B.	8. 3.60	24.67	13.00	18.84
11.	141 days at 40°F	"	16.00	12.42	14.21
12.	141 days without T.C.N.B. and then desprouted and sprouted in darkness	8. 3.60	9.67	12.42	11.05
	Mean		15.45	11.87	

S.E. of Variety ±0.338

S.E. of Treatment ±0.828

S.E. of Treatment x Variety ±1.17

TABLE 20

Number of sprouts per tuber at the end of the sprouting period in darkness for continuous and delayed sprouting treatments

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted throughout in darkness (Tr. 1)	4.92	10.75	7.83
Delayed sprouting (Tr. 2-12)	16.40	11.98	14.19
Difference	-11.48	-1.23	-6.36
		±1.22	±0.86

TABLE 21

Number of sprouts per tuber at the end of the sprouting period in darkness for desprouting and for delayed sprouting treatments without desprouting

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted in darkness after desprouting on 8.3.60 (Tr. 12)	9.67	12.42	11.05
Sprouted in darkness at intervals of four weeks from 19.11.59 to 8.3.60 without desprouting (Tr. 2-11)	17.08	11.92	14.50
Difference	-7.41	+0.50	-3.45
		±1.23	±0.87

TABLE 22

Number of sprouts per tuber at the end of the sprouting period, stored with T.C.N.B. and at 40°F for varying periods before sprouting in darkness

Period of Storage before Sprouting in Darkness	With T.C.N.B.	At 40°F i.e. No T.C.N.B.	Mean
31 days, i.e. sprouted on 19.11.59	12.62	11.71	12.17
57 days, i.e. sprouted on 15.12.59	15.46	12.42	13.94
85 days, i.e. sprouted on 12. 1.60	14.33	13.21	13.77
113 days, i.e. sprouted on 9. 2.60	19.09	13.17	16.13
141 days, i.e. sprouted on 8. 3.60	18.84	14.21	16.53
Mean	16.07	12.94	

S.E. of Treatment with T.C.N.B. and no T.C.N.B. ± 0.370

S.E. of Time of Sprouting ± 0.58

S.E. of Time of Sprouting x Treatment with T.C.N.B. and no T.C.N.B. ± 0.828

TABLE 23

Varietal difference in sprouts per tuber

Period of Storage before Sprouting in Darkness	Arran Pilot			Majestic		
	With T.C.N.B.	At 40^oF i.e. No T.C.N.B.	Mean	With T.C.N.B.	At 40^oF i.e. No T.C.N.B.	Mean
31 days, i.e. sprouted on 19.11.59	14.25	13.50	13.88	11.0	9.92	10.46
57 days, i.e. sprouted on 15.12.59	18.83	15.67	17.25	12.08	9.17	10.63
85 days, i.e. sprouted on 12. 1.60	15.83	14.75	15.29	12.83	11.67	12.25
113 days i.e. sprouted on 9. 2.60	22.75	14.58	18.67	15.42	11.75	13.59
141 days i.e. sprouted on 8. 3.60	24.67	16.00	20.39	13.00	12.42	12.71
Mean	19.26	14.90		12.87	10.99	

S.E. of Variety x Treatment with T.C.N.B. and no T.C.N.B. ± 0.52

S.E. of Variety x Time of Sprouting ± 0.828

S.E. of Variety x Time of Sprouting x Treatment with T.C.N.B. and no T.C.N.B. ± 1.17

tuber at the end of the sprouting period than March desprouting in Arran Pilot but no significant difference in effect between desprouting and the average of other sprouting treatments was found in Majestic (Table 21).

In comparing the effect of T.C.N.B. treatment with that of storage at low temperature, it is shown in Table 22 that the T.C.N.B. treatments gave rise to significantly more sprouts per tuber. This effect, however, was much more marked in Arran Pilot (Table 23).

Delay in the time of sprouting by previous storage with T.C.N.B. or at low temperature resulted in an increase in the number of sprouts produced per tuber, more especially with prolonged delay (Table 22) but the extent of the increase was much greater following T.C.N.B. treatment and in the variety Arran Pilot (Table 23).

In order to estimate to what extent variations in the numbers of sprouts per tuber were related to changes in the number of sprouts developed from eyes, the number of sprouted eyes per tuber and the mean number of sprouts per eye have been taken into account.

(ii) Number of Sprouted Eyes per Tuber

The number of eyes per tuber which produced sprouts at the end of the sprouting period in darkness (23rd April) for the various treatments is shown in Table 24 and the analysis of variance of the data is given in Appendix 19.

It may be seen from Table 24 that tubers of Arran Pilot

TABLE 24

Effect of varying periods of low temperature (40°F) storage and of T.C.N.B. treatment on the number of sprouted eyes per tuber at the end of the sprouting period in darkness (23rd April)

Tr. No.	Storage Period from 19th October and Storage Treatments	Date of Sprouting	Number of Sprouted Eyes per Tuber at the end of the Sprouting Period		
			Arran Pilot	Majestic	Mean
1.	Sprouted throughout in darkness	22.10.59	4.17	6.75	5.46
2.	31 days with T.C.N.B.	19.11.59	7.92	7.50	7.71
3.	31 days at 40°F	"	7.67	7.75	7.71
4.	57 days with T.C.N.B.	15.12.59	8.08	8.75	8.42
5.	57 days at 40°F	"	8.67	6.00	7.34
6.	85 days with T.C.N.B.	12. 1.60	7.42	7.83	7.63
7.	85 days at 40°F	"	8.17	6.75	7.46
8.	113 days with T.C.N.B.	9. 2.60	8.08	8.00	8.04
9.	113 days at 40°F	"	8.75	7.33	8.04
10.	141 days with T.C.N.B.	8. 3.60	9.50	6.92	8.21
11.	141 days at 40°F	"	8.92	7.92	8.41
12.	141 days without T.C.N.B. and then desprouted and sprouted in darkness	8. 3.60	8.00	8.00	8.00
	Mean		7.95	7.46	

S.E. of Variety ± 0.13

S.E. of Treatment ± 0.32

S.E. of Treatment x Variety ± 0.457

sprouted throughout the storage period gave fewer sprouted eyes per tuber than Majestic but showed a greater response to other treatments (related to T.C.N.B. and low temperature storage) and on average gave more sprouted eyes per tuber.

There was no difference in the number of eyes which developed sprouts between tubers desprouted in March and the average number developed on tubers from other storage treatments (T.C.N.B. and low temperature) which involved delay in the time of sprouting in either variety (Table 25).

TABLE 25

Number of sprouted eyes per tuber at the end of the sprouting period for desprouting and for delayed sprouting treatments

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted in darkness after desprouting on 8. 3.60 (Tr. 12)	8.00	8.00	8.00
Sprouted in darkness at intervals of four weeks from 19.11.59 to 8.3.60 without desprouting (Tr. 2-11)	8.31	7.47	7.89
Difference	-0.31	+0.53	+0.11
	±0.48		±0.34

No difference was found in comparing the effect of T.C.N.B. with low temperature storage prior to sprouting

TABLE 26

Number of sprouted eyes per tuber at the end of the sprouting period, stored with T.C.N.B. and at 40°F for varying periods before sprouting in darkness

Period of Storage before Sprouting in Darkness	With T.C.N.B.	At 40°F i.e. No T.C.N.B.	Mean
31 days, i.e. sprouted on 19.11.59	7.71	7.71	7.71
57 days, i.e. sprouted on 15.12.59	8.42	7.34	7.88
85 days, i.e. sprouted on 12. 1.60	7.63	7.46	7.54
113 days i.e. sprouted on 12. 1.60	8.04	8.04	8.04
141 days i.e. sprouted on 8. 3.60	8.21	8.41	8.31
Mean	8.00	7.79	

S.E. of Treatment with T.C.N.B. and no T.C.N.B. ± 0.14

S.E. of Time of Sprouting ± 0.228

S.E. of Time of Sprouting x Treatment with T.C.N.B. and no T.C.N.B. ± 0.32

TABLE 27

Varietal difference in sprouted eyes per tuber

Period of Storage before Sprouting in Darkness	Arran Pilot			Majestic		
	With T.C.N.B.	At 40°F i.e. No T.C.N.B.	Mean	With T.C.N.B.	At 40°F i.e. No T.C.N.B.	Mean
31 days, i.e. sprouted on 19.11.59	7.92	7.67	7.79	7.50	7.75	7.62
57 days, i.e. sprouted on 15.12.59	8.08	8.67	8.37	8.75	6.00	7.37
85 days, i.e. sprouted on 12. 1.60	7.42	8.17	7.79	7.83	6.75	7.29
113 days i.e. sprouted on 9. 2.60	8.08	8.75	8.41	8.00	7.33	7.66
141 days i.e. sprouted on 8. 3.60	9.50	8.92	9.21	6.92	7.92	7.42
Mean	8.20	8.44		7.80	7.15	

S.E. of Variety x Treatment with T.C.N.B. and no T.C.N.B. ± 0.20

S.E. of Variety x Time of Sprouting ± 0.32

S.E. of Variety x Time of Sprouting x Treatment with T.C.N.B. and no T.C.N.B. ± 0.457

taking the average of variety and different times of sprouting and also there was no general effect of time of sprouting on the number of eyes which developed sprouts (Table 26).

There was, however, an interaction effect between variety, time of sprouting and storage treatment. In Arran Pilot tubers stored with T.C.N.B. until March (141 days) formed a significantly greater number of sprouted eyes per tuber at the time of planting than those stored with T.C.N.B. for shorter periods, but the differences among November, December, January and February sprouted tubers were not significant. Tubers stored at low temperature (40°F) until March formed a significantly greater number of sprouted eyes per tuber than those sprouted during November but no other differences were significant for the different times of storage at low temperature (Table 27).

In Majestic there appeared to be no general trend in the effects of time of sprouting or in comparing T.C.N.B. with low temperature storage treatment. Storage with T.C.N.B. or at low temperature for 57 days does appear, however, to have given anomalous results and it is difficult to explain why the figures should be relatively high in the case of T.C.N.B. treatment and low in the case of low temperature storage treatment (Table 27).

TABLE 28

Effect of varying periods of low temperature ($40^{o}F$) storage and of T.C.N.B. treatment on the number of sprouts per eye

Tr. No.	Storage Period from 19th October and Storage Treatments	Date of Sprouting	Number of Sprouts per eye at the end of the Sprouting Period		
			Arran Pilot	Majestic	Mean
1.	Sprouted throughout in darkness	22.10.59	1.17	1.60	1.39
2.	31 days with T.C.N.B.	19.11.59	1.81	1.48	1.65
3.	31 days at $40^{o}F$	"	1.76	1.27	1.52
4.	57 days with T.C.N.B.	15.12.59	2.36	1.39	1.88
5.	57 days at $40^{o}F$	"	1.83	1.48	1.66
6.	85 days with T.C.N.B.	12. 1.60	2.12	1.62	1.87
7.	85 days at $40^{o}F$	"	1.77	1.72	1.75
8.	113 days with T.C.N.B.	9. 2.60	2.82	1.92	2.37
9.	113 days at $40^{o}F$	"	1.66	1.61	1.64
10.	141 days with T.C.N.B.	8. 3.60	2.60	1.85	2.23
11.	141 days at $40^{o}F$	"	1.78	1.58	1.68
12.	141 days without T.C.N.B. and then desprouted and sprouted in darkness	8. 3.60	1.22	1.55	1.39
	Mean		1.91	1.59	

S.E. of Variety ± 0.028

S.E. of Treatment ± 0.069

S.E. of Treatment x Variety ± 0.099

TABLE 29

Number of sprouts per eye at the end of the sprouting period in darkness for continuous and delayed sprouting treatments

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted throughout in darkness (Tr. 1)	1.17	1.60	1.39
Delayed sprouting (Tr. 2-12)	1.97	1.59	1.78
Difference	-0.80	+ .01	-0.39
	±0.10		±0.07

TABLE 30

Number of sprouts per eye at the end of the sprouting period in darkness for desprouting and for delayed sprouting treatments

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted in darkness after desprouting on 8.3.60 (Tr. 12)	1.22	1.55	1.39
Sprouted in darkness at intervals of four weeks from 19.11.59 to 8.3.60 without desprouting (Tr. 2-11)	2.05	1.59	1.82
Difference	-0.83	-0.04	-0.47
	±0.10		±0.07

(iii) Number of Sprouts per Eye

The effects of the various storage treatments on the average number of sprouts developed per eye at the end of the sprouting period (23rd April) in darkness is given in Table 28 and the analysis of variance of the results is shown in Appendix 21.

It can be seen from Table 28 that Arran Pilot produced more sprouts per eye (average for all treatment) than Majestic. However, this difference can be attributed to the greater effect of delayed storage on the early variety and it may be noted that Majestic tubers sprouted throughout or desprouted before the sprouting treatment started actually gave a greater number of sprouts per eye than Arran Pilot. Thus in comparison with sprouting throughout a significant increase from all other treatments in number of sprouts per eye was found only in Arran Pilot (Table 29) and it was again only in this variety that delayed sprouting gave on average a greater number of sprouts per eye than the desprouting treatments (Table 30).

In comparison with low temperature storage, T.C.N.B. treatments resulted on average in a greater number of sprouts per eye (Table 31). This effect at different times of sprouting was more consistent in Arran Pilot where significant increases from T.C.N.B. treatment were found from December onwards whereas in Majestic the differences were only significant when the storage period previous to sprouting continued until February onwards (Table 32).

TABLE 31

Number of sprouts per eye at the end of the sprouting period for tubers stored at 40°F and after T.C.N.B. treatment for varying periods before sprouting in darkness

Period of Storage before Sprouting in Darkness	With T.C.N.B.	At 40°F i.e. No T.C.N.B.	Mean
31 days, i.e. sprouted on 19.11.59	1.65	1.52	1.58
57 days, i.e. sprouted on 15. 12.59	1.88	1.66	1.77
85 days, i.e. sprouted on 12. 1.60	1.87	1.75	1.81
113 days i.e. sprouted on 9. 2.60	2.37	1.64	2.00
141 days i.e. sprouted on 8. 3.60	2.23	1.68	1.95
Mean	2.00	1.65	

S.E. of Treatment with T.C.N.B. and no T.C.N.B. ±0.03

S.E. of Time of Sprouting ±0.049

S.E. of Time of Sprouting x Treatment with T.C.N.B. and no T.C.N.B. ±0.069

TABLE 32

Varietal difference in sprouts per eye

Period of Storage before Sprouting in Darkness	Arran Pilot			Majestic		
	With T.C.N.B.	At $40^{o}F$ i.e. No T.C.N.B.	Mean	With T.C.N.B.	At $40^{o}F$ i.e. No T.C.N.B.	Mean
31 days, i.e. sprouted on 19.11.59	1.81	1.76	1.78	1.48	1.27	1.37
57 days, i.e. sprouted on 15.11.59	2.36	1.83	2.09	1.39	1.48	1.43
85 days, i.e. sprouted on 12. 1.60	2.12	1.77	1.95	1.62	1.72	1.67
113 days i.e. sprouted on 9. 2.60	2.82	1.66	2.24	1.92	1.61	1.76
141 days i.e. sprouted on 8. 3.60	2.60	1.78	2.19	1.85	1.58	1.71
Mean	2.34	1.76		1.65	1.53	

S.E. of Variety x Treatment with T.C.N.B. and no T.C.N.B. ± 0.04

S.E. of Variety x Time of Sprouting ± 0.069

S.E. of Variety x Time of Sprouting x Treatment with T.C.N.B. and no T.C.N.B. ± 0.099

Increasing the period of delay before sprouting tended to cause an increase in the number of sprouts per eye and the main effects were significant when comparing November sprouting with all later times of sprouting and in comparing December and January sprouting with sprouting commenced in February and March (Table 31). There was, however, a significant interaction between variety and storage treatments and time of sprouting and effects were much more marked with T.C.N.B. treatment and in Arran Pilot. Thus Arran Pilot tubers previously treated with T.C.N.B. and sprouted during December and January formed a significantly greater number of sprouts per eye than those sprouted during November, and similarly tubers sprouted during February and March formed a significantly greater number of sprouts per eye than those sprouted during November, December and January. With low temperature storage, however, there was no significant difference in number of sprouts per eye between November, December, January, February and March sprouted tubers (Table 32).

In Majestic longer periods of storage with T.C.N.B. until February and March resulted in a significantly greater number of sprouts per eye than those stored until November, December and January. With low temperature storage, tubers sprouted during November formed a significantly smaller number of sprouts per eye than those sprouted during January, February and March (Table 32).

TABLE 33

Effect of varying periods of low temperature (40°F) storage and of T.C.N.B. treatment on sprout weight

Tr. No.	Storage Period from 19th October and Storage Treatments	Date of Sprouting	Sprout weight as percentage of final weight of potato at end of sprouting period in darkness		
			Arran Pilot	Majestic	Mean
1.	Sprouted throughout in darkness	22.10.59	50.85	17.68	34.26
2.	31 days with T.C.N.B.	19.11.59	51.83	22.89	37.36
3.	31 days at 40°F	"	52.02	21.16	36.59
4.	57 days with T.C.N.B.	15.12.59	41.97	19.43	30.70
5.	57 days at 40°F	"	54.70	27.52	41.11
6.	85 days with T.C.N.B.	12. 1.60	22.36	12.37	17.37
7.	85 days at 40°F	"	31.78	14.79	23.28
8.	113 days with T.C.N.B.	9. 2.60	17.93	8.73	13.33
9.	113 days at 40°F	"	19.03	6.73	12.88
10.	141 days with T.C.N.B.	8. 3.60	12.35	6.24	9.29
11.	141 days at 40°F	"	12.87	5.92	9.40
12.	141 days without T.C.N.B. and then desprouted and sprouted in darkness	8. 3.60	17.17	4.77	10.97
	Mean		32.07	14.01	

S.E. of Variety ± 0.586

S.E. of Treatment ± 1.437

S.E. of Treatment x Variety ± 2.03

(iv) Sprout Weight

Before planting, tubers were desprouted and the sprout weight has been expressed as a percentage of the final weight of the mother tuber (Table 33). The analysis of variance of the data is given in Appendix 22.

Arran Pilot, a vigorous sprouting variety, showed a significantly greater amount of sprout growth at the time of planting than Majestic, a slow sprouting variety, from all comparable treatments (Table 33).

Delay in the time of sprouting resulted, on average, in a smaller weight of sprouts at the end of the sprouting period than continuous sprouting throughout the storage period (Table 34). However, in Arran Pilot tubers sprouted

TABLE 34

Sprout weight as percentage of final weight of potato at the end of the sprouting period in darkness for continuous and delayed sprouting treatments

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted throughout in darkness (Tr. 1)	50.85	17.68	34.26
Delayed sprouting (Tr. 2-12)	30.36	13.86	22.02
Difference	+20.49	+3.82	+12.24
	±2.12		± 1.50

throughout in darkness did not give a greater relative sprout weight per tuber than those sprouted after 31 days with T.C.N.B. or at 40°F and 57 days at low temperature. In Majestic, tubers sprouted throughout did not show a greater sprout weight than those sprouted after 31 days and 57 days irrespective of T.C.N.B. treatments (Table 33). It seems that initially dormant tubers did not form a greater quantity of sprouts during sprouting in darkness compared with those sprouted after 31 or 57 days. Burton (1952c) also reported that the weight of sprouts produced by the non-dormant tubers after 73 days at 10°C was six times as great as that produced after 105 days by tubers initially dormant.

The desprouting treatment resulted in a smaller weight of sprouts than the average of other storage treatments (Table 35) but in Arran Pilot a greater amount of sprout growth was produced from desprouted tubers than from tubers sprouted at the same time after previous storage at low temperature or with T.C.N.B. (Table 33). Thus in Arran Pilot desprouted tubers which had shown active sprout growth formed a greater weight of sprouts during second sprouting in darkness compared with tubers stored at 40°F or with T.C.N.B. where sprout growth had been suppressed and the dormant period prolonged. In Majestic, on the other hand, tubers were in a less active growth condition at the time of desprouting which may be related to the longer period of dormancy on this variety and hence the

TABLE 35

Sprout weight as percentage of final weight of potato at the end of the sprouting period in darkness for desprouting and for delayed sprouting treatments

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted in darkness after desprouting on 8.3.60 (Tr. 12)	17.17	4.77	10.97
Sprouted in darkness at intervals of four weeks from 19.11.59 to 8.3.60 without desprouting (Tr. 2-11)	31.68	14.58	23.13
	-14.51	-9.81	-12.16
		±2.15	± 1.50

physiological condition of the tubers probably differed little from those of tubers held at 40°F or with T.C.N.B. treatment.

Tubers stored at 40°F without T.C.N.B. before sprouting in darkness had a significantly greater relative sprout weight than those stored with T.C.N.B. (Table 36). For the different times of sprouting, however, the effect was only significant with tubers sprouted in December and January. Table 36 also illustrates the trend towards a reduction in sprout weight with longer period of storage.

With regard to the effect of time of sprouting in the

TABLE 36

Sprout weight as percentage of final weight of tuber at the end of the sprouting period for tubers stored at 40°F and after T.C.N.B. treatment for varying periods before sprouting in darkness

Period of Storage before Sprouting in Darkness	With T.C.N.B.	At 40°F i.e. No T.C.N.B.	Mean
31 days, i.e. sprouted on 19.11.59	37.36	36.59	36.97
57 days, i.e. sprouted on 15.12.59	30.70	41.11	35.90
85 days, i.e. sprouted on 12. 1.60	17.37	23.28	20.32
113 days i.e. sprouted on 9. 2.60	13.33	12.88	13.10
141 days i.e. sprouted on 8. 3.60	9.29	9.40	9.34
Mean	21.61	24.65	

S.E. of Treatment with T.C.N.B. and no T.C.N.B. ±0.64

S.E. of Time of Sprouting ±1.016

S.E. of Time of Sprouting x Treatment with or without T.C.N.B. ±1.437

TABLE 37

Sprout weight as percentage of final weight of tuber at the end of sprouting period of Arran Pilot and Majestic tubers stored for different periods with or without T.C.N.B. before sprouting in darkness

Period of Storage before Sprouting in Darkness	Arran Pilot			Majestic		
	With T.C.N.B.	At $40^{\circ}F$ i.e. No T.C.N.B.	Mean	With T.C.N.B.	At $40^{\circ}F$ i.e. No T.C.N.B.	Mean
31 days, i.e. sprouted on 19.11.59	51.83	52.02	51.92	22.89	21.16	22.02
57 days, i.e. sprouted on 15.12.59	41.97	54.70	48.33	19.43	27.52	23.47
85 days, i.e. sprouted on 12. 1.60	22.36	31.78	27.07	12.37	14.79	13.58
113 days i.e. sprouted on 9. 2.60	17.93	19.03	18.48	8.73	6.73	7.73
141 days i.e. sprouted on 8. 3.60	12.35	12.87	12.61	6.24	5.92	6.08
Mean	29.29	34.08		13.93	15.22	

S.E. of Variety x Treatment with T.C.N.B. and no T.C.N.B. ± 0.908

S.E. of Variety x Time of Sprouting ± 1.437

S.E. of Variety x Time of Sprouting x Treatment with T.C.N.B. and no T.C.N.B. ± 2.03

two varieties, it can be seen from Table 37 that in Arran Pilot for each month's delay in sprouting after December there was a significant reduction in relative sprout weight. In Majestic a similar trend was shown but the differences between November and December and between February and March sprouting respectively were not significant.

Although there was a reduction in the relative weight of sprouts with delay in sprouting, it may be seen from Table 38 that the vigour of sprout growth (assessed as the total length of sprouts per tuber) during the first four weeks of sprouting increased with the age of the tuber over the period October to February.

TABLE 38

Effect of time of sprouting in darkness on the vigour of sprout growth

Storage Period before Sprouting in Darkness	Growth in total sprout length (mm) during the first four weeks of sprouting in darkness		Mean
	Arran Pilot	Majestic	
Sprouted from the beginning i.e. sprouted in October	4.83	0	2.41
31 days i.e. sprouted in November	112.46	8.08	60.27
57 days i.e. sprouted in December	130.50	25.58	78.04
85 days i.e. sprouted in January	156.25	35.50	95.87
113 days i.e. sprouted in February	473.61	104.83	289.22

B. Rate of Plant Emergence

The percentage of plant emergence at successive dates after planting is shown in Appendix 23. The results for average number of days to emergence for plants that did emerge and the percentage blanking on the final date of counting, 55 days after planting, are summarised in Table 39. It may be seen from Table 39 that prolonged periods of sprouting before desprouting had an adverse effect on the final emergence in Arran Pilot and gave incomplete plant stand in all cases where sprouting commenced before January.

The mean "Germination Rate Index" for different storage treatments and the analysis of variance of the results are shown in Table 40 and Appendix 24 respectively.

The effect of variety, treatment with T.C.N.B. and time of sprouting from low temperature and T.C.N.B. on "Germination Rate Index" was significant (Appendix 24). These effects might all be related, at least in part, to influence of degree of sprout loss. Thus Majestic, which produced lower sprout weight (average of all treatment) at the time of desprouting (Table 33) emerged earlier than Arran Pilot (Table 39 and 40). Again delay in sprouting in darkness which reduced the sprout loss (Table 36) resulted in earlier plant emergence (Table 41). Similarly, treatment with T.C.N.B. before sprouting in darkness tended to result in a smaller amount of sprout development (Table 36) than storage at 40°F, and consequently plant emergence was earlier in the former case (Table 41). In

TABLE 39

Effect of varying periods of sprouting in darkness and desprouting at the time of planting on the average number of days to plant emergence and percentage blanking

Tr. No.	Storage Period from October and Storage Treatments	Date of Sprouting	Average number of days to Plant Emergence		Percentage Blanking	
			Arran Pilot	Majestic	Arran Pilot	Majestic
1.	Sprouted throughout in darkness	22.10.59	29.17	24.67	25.00	0.00
2.	31 days with T.C.N.B.	19.11.59	31.00	26.33	41.66	0.00
3.	31 days at 40^{o}F	"	29.12	28.17	41.66	0.00
4.	57 days with T.C.N.B.	15.12.59	26.04	23.66	8.33	0.00
5.	57 days at 40^{o}F	"	32.42	26.92	41.60	0.00
6.	85 days with T.C.N.B.	12. 1.60	24.25	21.16	0.00	0.00
7.	85 days at 40^{o}F	"	26.25	25.50	0.00	0.00
8.	113 days with T.C.N.B.	9. 2.60	21.44	23.25	0.00	0.00
9.	113 days at 40^{o}F	"	26.16	25.25	0.00	0.00
10.	141 days with T.C.N.B.	8. 3.60	21.33	22.66	0.00	0.00
11.	141 days at 40^{o}F	"	25.00	23.58	0.00	0.00
12.	141 days without T.C.N.B. and then desprouted and sprouted in darkness	8. 3.60	25.17	23.08	0.00	0.00
	Mean		26.44	24.52		

TABLE 40

Effect of varying periods of sprouting in darkness and desprouting at the time of planting on the "Germination Rate Index"

Tr. No.	Storage Period from 19th October and Storage Treatments	Date of Sprouting	Germination Rate Index		
			Arran Pilot	Majestic	Mean
1.	Sprouted throughout in darkness	22.10.59	0.556	0.704	0.630
2.	31 days with T.C.N.B.	19.11.59	0.500	0.649	0.574
3.	31 days at 40°F	"	0.556	0.593	0.574
4.	57 days with T.C.N.B.	15.12.59	0.662	0.732	0.697
5.	57 days at 40°F	"	0.454	0.630	0.542
6.	85 days with T.C.N.B.	12. 1.60	0.713	0.806	0.749
7.	85 days at 40°F	"	0.639	0.676	0.657
8.	113 days with T.C.N.B.	9. 2.60	0.806	0.741	0.773
9.	113 days at 40°F	"	0.658	0.686	0.672
10.	141 days with T.C.N.B.	8. 3.60	0.778	0.760	0.769
11.	141 days at 40°F	"	0.695	0.732	0.713
12.	141 days without T.C.N.B. and then desprouted and sprouted in darkness	8. 3.60	0.686	0.750	0.718
	Mean		0.642	0.705	

S.E. of Variety ±0.0117

S.E. of Treatment ±0.0357

S.E. of Treatment x Variety ±0.050

TABLE 41

"Germination Rate Index" for tubers stored at $40^{\circ}F$ and with T.C.N.B. for varying periods before sprouting in darkness and desprouted at the time of planting

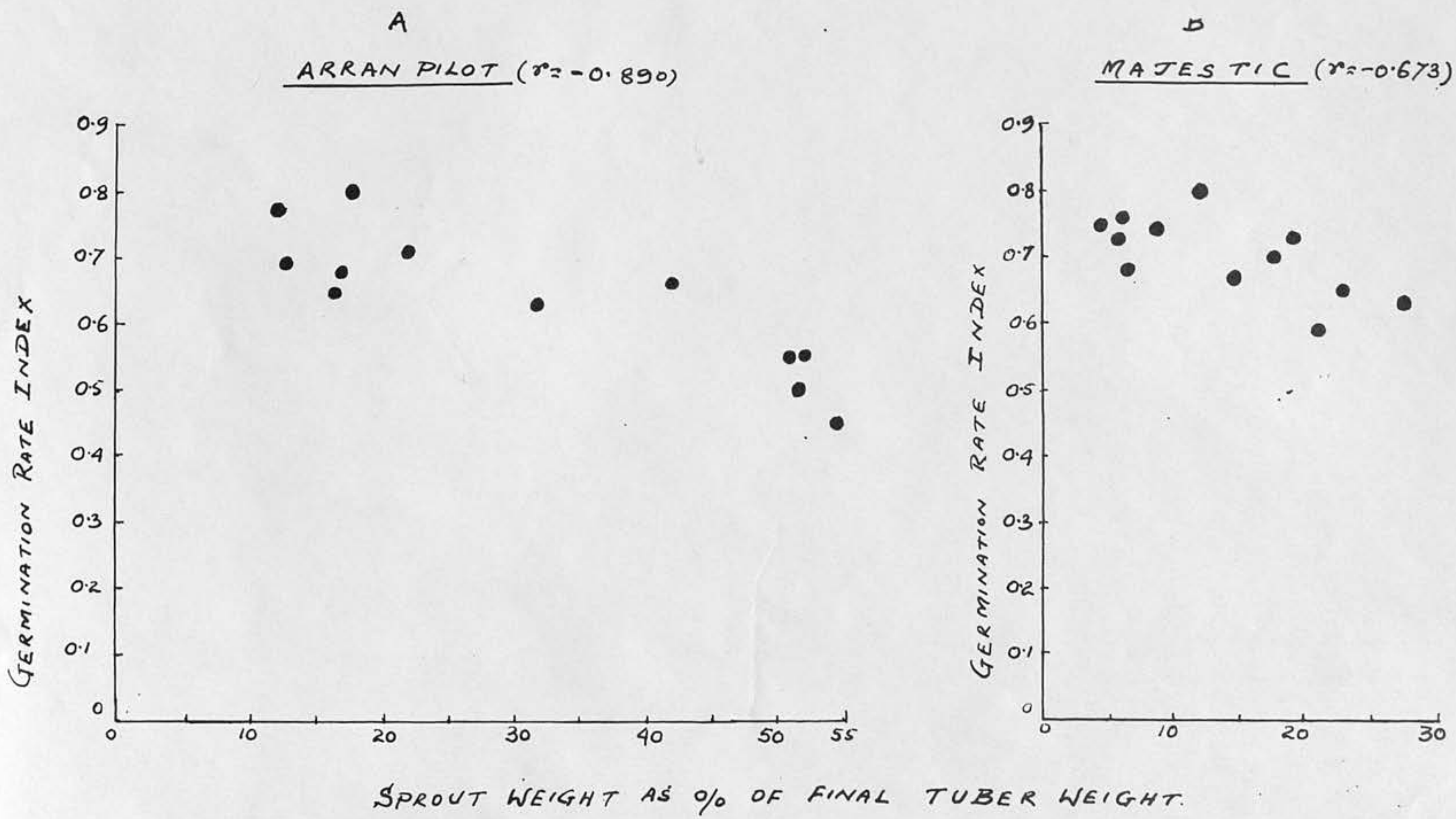
Period of Storage before Sprouting in Darkness	With T.C.N.B.	At $40^{\circ}F$ i.e. No T.C.N.B.	Mean
31 days, i.e. sprouted on 19.11.59	0.574	0.574	0.574
57 days, i.e. sprouted on 15.12.59	0.697	0.542	0.619
85 days, i.e. sprouted on 12. 1.60	0.759	0.659	0.708
113 days i.e. sprouted on 9. 2.60	0.773	0.672	0.722
141 days i.e. sprouted on 8. 3.60	0.769	0.713	0.741
Mean	0.714	0.632	

S.E. of Treatment with T.C.N.B. and no T.C.N.B. ± 0.0159

S.E. of Time of Sprouting ± 0.0178

S.E. of Time of Sprouting x Treatment with or without T.C.N.B. ± 0.0357

Fig.7 RELATIONSHIP BETWEEN SPROUT WEIGHT AS PERCENTAGE OF FINAL TUBER WEIGHT AND GERMINATION RATE INDEX(EACH POINT REPRESENTING A TREATMENT MEAN).



relating rate of plant emergence with previous sprout loss, a significant negative correlation was found in both Arran Pilot ($r = -0.890$) and Majestic ($r = -0.673$) between sprout loss expressed as a percentage of final weight of the tuber and the "Germination Rate Index" (Fig. 7 A and B).

C. DISCUSSION

EXPERIMENT 2

When sprouting was carried out in darkness the number of sprouts which developed was again found to depend on the time of sprouting following varying periods of storage at low temperature with or without T.C.N.B. As in the case of sprouting in light in Experiment 1, delay in time of sprouting caused an increase in the number of sprouts per tuber and again this may be related to the concept of apical dominance (Appleman 1925, Kawakami 1953) during the early sprouting phase of the tuber followed by a multiple sprouting condition (Bushnell 1929, Toosey 1959, Hiele 1961). This trend towards an increase in sprout numbers per tuber with delay in sprouting was found in both varieties but was less marked in Majestic, which showed in general a smaller range of variation in sprout numbers resulting from the various treatments compared with Arran Pilot. As with delayed sprouting in light, the increased numbers of sprouts per tuber with delay in sprouting in darkness was due in part to an increase in the number of eyes which developed sprouts but mostly to the increase in sprouts per eye. The most marked increases in sprout numbers were found in Arran Pilot following prolonged storage (October to February or March) with T.C.N.B.and this was related primarily to the large number of sprouts produced per eye, giving a result similar to that when sprouting was carried out in light.

While sprout numbers tended to increase with the delay in sprouting, the weight of sprouts developed at the end of the sprouting period decreased with the shorter periods of sprouting, as would be expected. Exceptions did occur, however, with the earlier sprouting treatments. Thus tubers of both varieties sprouted after 31 days with or without T.C.N.B. and 57 days without T.C.N.B., and 57 days with T.C.N.B. in the case of Majestic tended to give a greater relative sprout weight than those sprouted throughout in darkness. The smaller sprout weight (expressed as a percentage of the final tuber weight) in tubers sprouted from the beginning of the storage period (i.e. for 184 days) compared with those sprouted after 31 days (i.e. sprouting period 156 days) or 57 days (sprouting period 130 days) may be related to the initial dormant condition of the tuber in the former case. These results support the evidence of Burton (1952c) who found that the weight of sprouts produced by non-dormant tubers after 73 days at 10°C was six times as great as that produced after 105 days by tubers initially dormant.

In comparing T.C.N.B. and no T.C.N.B. treatments (averaged for variety and time of sprouting) tubers stored with T.C.N.B. gave a smaller relative sprout weight than those stored without T.C.N.B. While treatment with T.C.N.B. tended to retard subsequent sprout growth, the effect was not marked and significant differences in favour of no

T.C.N.B. treatment for greater relative sprout weight were only found in Arran Pilot when tubers were sprouted during December and January and in Majestic for tubers sprouted in December, but in all other comparisons the differences in sprout weight between comparable T.C.N.B. and no T.C.N.B. treatments were not significant.

Although in both varieties there was a reduction in the relative sprout weight at the end of the sprouting period with delay in sprouting, the vigour of sprout growth (assessed as the total length of sprouts per tuber) during the first four weeks of sprouting increased with the age of the tuber over the period of observations from October to February, and these results are in agreement with those of Krijthe (1958) who showed that from the time of lifting onwards to a certain stage of life the germinating power of the potato tuber increased with the age of the tuber.

In both varieties there was a significant negative correlation between sprout loss (expressed as a percentage of the final weight of the tuber) and the "Germination Rate Index". Moreover, prolonged periods of sprouting in darkness before desprouting had an adverse effect on final emergence in Arran Pilot and gave an incomplete plant stand, where sprouting commenced before January and sprout losses exceeded 40% (sprouts as percentage of final weight of tuber). In Majestic where sprout losses did not exceed 27.5% complete plant stands were found.

Earlier emergence associated with delay in sprouting in darkness (averaged for variety and treatment with T.C.N.B.) may be related to a decrease in sprout loss with later sprouting. However, the results showed that differences in rates of plant emergence between tubers sprouted during January, February and March (averaged for variety and treatment with T.C.N.B.) and desprouted at the time of planting, were not significant which suggests that sprout losses up to 20.3% had no significant effect on the rate of plant emergence.

D. CONCLUSIONS

EXPERIMENT 2

In Experiment 2 studies were carried out on the effect of varying periods of storage of seed tubers with T.C.N.B. or at low temperature on subsequent sprouting in darkness and plant emergence in Arran Pilot and Majestic after desprouting before planting.

1. Delaying the time of sprouting by prolonging the period of storage at low temperature with or without T.C.N.B. until January before sprouting in darkness resulted in an increase in sprout number, but with further delay in sprouting until February or March the increase in sprout number was less marked in no T.C.N.B. treatment, whereas T.C.N.B. treated tubers continued to give a larger number of sprouts. This trend towards an increase in sprout number with delay in sprouting was found in both varieties but was less marked in Majestic which showed in general a smaller range of variation in sprout numbers resulting from different treatments compared with Arran Pilot.

2. The increased sprout numbers with delay in sprouting in darkness was due in part to an increase in the number of eyes which developed sprouts but mostly to the increase in sprouts per eye.

3. As with sprouting in light, tubers of Arran Pilot stored over prolonged periods (October to February or March)

and previously treated with T.C.N.B. during storage at low temperature resulted subsequently in a marked increase in sprout number at the end of sprouting period in darkness over those stored without T.C.N.B. This effect of T.C.N.B. was not found in Majestic.

4. Treatment with T.C.N.B. before sprouting in darkness tended to retard subsequent sprout growth; the effect was not marked and significant differences in favour of no T.C.N.B. treatment for greater growth of sprout were only found in both varieties when tubers were sprouted in December and in Arran Pilot sprouted in January.

5. The vigour of sprout growth (i.e. growth of sprout in total length during first four weeks of sprouting in darkness) increased with the age of the tuber over the period of observation from October to February.

6. A significant negative correlation between the amount of sprout loss and the rate of plant emergence was noted. However, a sprout loss up to 20.3% (averaged for varieties) had no significant effect on the rate of plant emergence.

7. Arran Pilot gave an incomplete plant stand where sprouting in darkness commenced before January and sprout losses exceeded 40%, whereas in Majestic where sprout losses did not exceed 27.5% full plant stands were obtained in all cases.

Experiment 3. Effect of desprouting after varying periods of storage on sprouting in light or darkness and on plant emergence in the field.

RESULTS

A. Observations during Storage Period

(i) Number of Sprouts per Tuber

The number of sprouts per tuber recorded at the end of the sprouting period (24th April) for the various treatments are shown in Appendix 28. From the analysis of variance of the data effects of time of desprouting and light were found to be significant.

Tubers sprouted in light (average of varieties and time of desprouting) formed a significantly greater number of sprouts per tuber than those sprouted in darkness (Table 42). However, a significant difference in favour of sprouting in light for a greater number of sprouts was found when apical eyes were removed and sprouted throughout.

In considering the effect of time of desprouting, it was found that tubers desprouted after 123 and 137 days of sprouting in darkness formed a significantly greater number of sprouts per tuber irrespective of whether resprouting was carried out in light or darkness than those sprouted throughout with or without apical eyes (Table 42). No significant difference in effect was found between the different times of desprouting (Table 42). However, varieties did respond differently to the treatments. Arran

TABLE 42

Effect of desprouting after varying periods of storage on the number of sprouts per tuber at the end of the sprouting period in light and darkness (24th April)

Storage Treatment Commencing from 22nd October	Light	Darkness	Mean
Sprouted throughout in	8.13	7.30	7.71
Apical eyes removed and sprouted throughout in	9.96	5.88	7.92
Sprouted in darkness for 123 days and then desprouted and resprouted in	12.00	10.58	11.29
Sprouted in darkness for 137 days and then desprouted and resprouted in	13.17	11.42	12.29
Mean	10.81	8.79	

S.E. of Light and Darkness ± 0.106
S.E. of Time of Desprouting ± 0.150
S.E. of Time of Desprouting x Light and Darkness ± 0.67

Pilot tubers desprouted after 123 and 137 days of sprouting in darkness gave rise to a significantly greater number of sprouts per tuber at the end of the sprouting period than those sprouted continuously or following removal of apical eyes at the beginning of the sprouting period. On the other hand, in Majestic there was no significant difference

TABLE 43

Effect of time of desprouting on the number of sprouts per tuber in Arran Pilot and Majestic at the end of the sprouting period (24th April)

Storage Treatment Commencing from 22nd October	Arran Pilot	Majestic
Sprouted throughout	7.00	8.42
Apical eyes removed and sprouted throughout	5.79	10.04
Sprouted in darkness for 123 days and then desprouted and resprouted	12.12	10.45
Sprouted in darkness for 137 days and then desprouted and resprouted	13.41	11.16

S.E. of Variety x Time of Desprouting ± 0.67

between the effects of removal of eyes at the beginning and desprouting after 123 or 137 days storage although tubers from both desprouting treatments gave more sprouts than intact tubers sprouted from the beginning of the experiment. Arran Pilot tended to form fewer sprouts after removal of apical eyes than Majestic but desprouting after 123 and 137 days of sprouting in darkness gave slightly more sprouts in comparison with Majestic (Table 43).

In order to estimate to what extent variation in the number of sprouts per tuber was related to changes in the number of eyes which produced sprouts or in the number of

TABLE 44

Effect of desprouting after varying periods of storage on the number of sprouted eyes per tuber at the end of the sprouting period in light and darkness (24th April)

Storage Treatment Commencing from 22nd October	Light	Darkness	Mean
Sprouted throughout in	6.58	5.87	6.23
Apical eyes removed and sprouted throughout in	7.17	4.42	5.79
Sprouted in darkness for 123 days and then desprouted and resprouted in	7.83	7.25	7.54
Sprouted in darkness for 137 days and then desprouted and resprouted in	7.95	7.54	7.74
Mean	7.38	6.27	

S.E. of Light and Darkness ± 0.196
S.E. of Time of Desprouting ± 0.278
S.E. of Time of Desprouting x Light and Darkness ± 0.39

sprouts developed from eyes, the number of sprouted eyes per tuber and the mean number of sprouts per eye have been taken into account.

(ii) Number of Sprouted Eyes per Tuber

The effect of different treatments on the number of sprouted eyes per tuber at the end of the sprouting period

(24th April) and the analysis of variance of the data are shown in Appendix 30 and Appendix 31 respectively.

Tubers sprouted in light gave rise to a greater number of sprouted eyes per tuber, irrespective of the time of desprouting, than those sprouted in darkness. However, the increases were only significant when sprouting continued throughout the storage period after removal of apical eyes (Table 44).

The main effect of time of desprouting showed that tubers desprouted after 123 and 137 days of sprouting in darkness gave a significantly greater number of sprouted eyes per tuber than those sprouted throughout with or without the apical eyes intact (Table 44). However, the effect varied according to whether sprouting took place in light or darkness. In darkness tubers sprouted throughout after removal of apical eyes gave significantly fewer sprouted eyes than intact tubers and tubers from both of these treatments produced significantly fewer sprouted eyes than the tubers desprouted after 123 or 137 days. In light there was no significant difference between intact tubers and those with apical eyes removed and desprouting after 123 and 137 days gave rise to a significantly greater number of sprouted eyes only in comparison with those sprouted continuously with eyes intact (Table 44).

In comparing time of desprouting within each variety, it was found that 123 and 137 days desprouting treatment formed a significantly greater number of sprouted eyes compared with continuous sprouting (with or without apical eyes removed) only in Arran Pilot: the increase was not significant in Majestic (Table 45).

TABLE 45

Effect of time of desprouting on the number of sprouted eyes per tuber in Arran Pilot and Majestic at the end of the sprouting period (24th April)

Storage Treatment Commencing from 22nd October	Arran Pilot	Majestic
Sprouted throughout	5.92	6.54
Apical eyes removed and sprouted throughout	5.00	6.58
Sprouted in darkness for 123 days and then desprouted and resprouted	8.33	6.75
Sprouted in darkness for 137 days and then desprouted and resprouted	8.37	7.12

S.E. of Variety x Time of Desprouting ± 0.278

(iii) Number of Sprouts per Eye

The number of sprouts per eye recorded at the end of the sprouting period from the different storage treatment and the analysis of variance of data are presented in Appendix 32 and Appendix 33 respectively.

The number of sprouts per eye was found to vary with variety, sprouting in light or darkness and time of

TABLE 46

Effect of desprouting after varying periods of storage on the number of sprouts per eye at the end of the sprouting period in light and darkness (24th April)

Storage Treatment Commencing from 22nd October	Light	Darkness	Mean
Sprouted throughout in	1.22	1.20	1.21
Apical eyes removed and sprouted throughout in	1.40	1.27	1.33
Sprouted in darkness for 123 days and then desprouted and resprouted in	1.55	1.49	1.52
Sprouted in darkness for 137 days and then desprouted and resprouted in	1.67	1.53	1.60
Mean	1.46	1.37	

S.E. of Light and Darkness ±0.03
S.E. of Time of Desprouting ±0.04
S.E. of Time of Desprouting x Light and Darkness ±0.06

desprouting (Appendix 33). It can be seen from Table 46 that sprouting in light gave rise to a significantly greater number of sprouts per eye than sprouting in darkness (average of time of desprouting); however, on a particular date of desprouting the difference in favour of increased number of sprouts per eye in sprouting in light was not significant. Tubers desprouted after 123 and 137 days in darkness subsequently produced a greater number of sprouts per eye than those sprouted from the beginning of the storage period either intact or with apical eyes removed (Table 46).

Majestic produced on average a greater number of sprouts per eye than Arran Pilot but the increase can be attributed to the effect of removing apical eyes (Appendix 32).

(iv) Longest Length of Sprouts per Tuber at the End of the Sprouting Period (24th April)

As would be expected, the longest sprout length was generally greater in Arran Pilot than in Majestic for comparable treatments and in both varieties, irrespective of period of sprouting, the longest length of sprout was markedly longer where sprouting was carried out in darkness (Table 47). Shorter periods of sprouting gave correspondingly shorter lengths of sprout in both varieties (Table 47).

B. Rate of Plant Emergence

The percentage of plant emergence at successive dates after planting and the average number of days to emergence are shown in Appendix 34 and Table 48 respectively. For the purpose of statistical analysis the data has been considered on the basis of the "Germination Rate Index" formulated by Bartlett (1937). The mean "Germination Rate

TABLE 47

Effect of desprouting after varying periods of storage on the length (mm.) of longest sprout per tuber at the end of the sprouting period in light and darkness (24th April)

Storage Treatment Commencing from 22nd October	Arran Pilot		Majestic	
	Light	Darkness	Light	Darkness
Sprouted throughout in	34.9	636.7	16.1	407.1
Apical eyes removed and sprouted throughout in	35.7	696.2	17.1	219.3
Sprouted in darkness for 123 days and then desprouted and resprouted in	25.1	340.0	15.0	239.6
Sprouted in darkness for 137 days and then desprouted and resprouted in	14.6	195.4	13.3	178.3

Index" of different storage treatments and the analysis of variance of data are presented in Appendix 35 and Appendix 36 respectively.

Removal of sprouts at the time of planting caused a significantly slower rate of plant emergence than that of tubers planted with sprouts intact (Table 49). It can be seen in Table 48 and Appendix 34 that in both varieties tubers desprouted at the time of planting took maximum time to emerge. Arran Pilot tubers sprouted throughout in

TABLE 48

Effect of desprouting after varying periods of storage and resprouting in light and darkness on the average number of days to plant emergence in Arran Pilot and Majestic

Storage Treatment Commencing from 22nd October	Arran Pilot			Majestic		
	Light	Darkness	Mean	Light	Darkness	Mean
Sprouted throughout in	17.92	23.42	20.67	17.50	22.17	19.83
Apical eyes removed and sprouted throughout in	17.83	22.92	20.37	17.58	19.33	18.45
Sprouted in darkness for 123 days and then desprouted and resprouted in	20.83	19.17	20.00	19.75	21.67	20.71
Sprouted in darkness for 137 days and then desprouted and resprouted in	22.92	16.33	19.62	18.25	17.25	17.75
Sprouted throughout in darkness and desprouted at the time of planting		32.78				26.92

TABLE 49

Effect of planting with or without sprouts on the "Germination Rate Index" of Arran Pilot and Majestic

Storage Treatment Commencing from 22nd October	Germination Rate Index		
	Arran Pilot	Majestic	Mean
Sprouted throughout in darkness and desprouted at the time of planting	0.342	0.519	0.430
Sprouted for varying periods in light and darkness and planted with sprouts	0.734	0.764	0.749
Difference	-0.392	-0.245	-0.319
		±0.056	±0.040

darkness and desprouted at the time of planting showed incomplete plant stand (75%).

In comparing the effects of desprouting and resprouting in light or darkness, it was found that delay in desprouting and resprouting in light caused a slow rate of plant emergence, whereas delay in desprouting and resprouting in darkness gave earlier emergence of plants (Table 50 and Appendix 34). This emergence behaviour associated with time of desprouting and resprouting in light or darkness was found to a greater or lesser extent in both varieties (Table 48). It may be noted that tubers sprouted throughout in darkness having very long (696.7 mm. in Arran Pilot

TABLE 50

Effect of desprouting after varying periods of storage and resprouting in light and darkness on the "Germination Rate Index"

Storage Treatment Commencing from 22nd October	Light	Darkness
Sprouted throughout in	0.810	0.648
Apical eyes removed and sprouted throughout in	0.810	0.704
Sprouted in darkness for 123 days and then desprouted and resprouted in	0.731	0.727
Sprouted in darkness for 137 days and then desprouted and resprouted in	0.722	0.838
Mean	0.768	0.729

S.E. of Light and Darkness ±0.016
S.E. of Time of Desprouting x Light and Darkness ±0.0377

and 407.1 mm. in Majestic) and etiolated sprouts, emerged later (5 to 6 days) than those sprouted for the same period in light (35.7 mm. sprout length in Arran Pilot and 17.1 mm. in Majestic). On the contrary, tubers desprouted after 137 days and resprouted in darkness (195.4 mm. sprout length in Arran Pilot and 178.3 mm. in Majestic) produced plants above ground earlier (2 to 6 days) than those sprouted in light (14.6 mm. sprout length in Arran Pilot and

13.3 mm. in Majestic) [Table 48]. It seems from the above results that sprouting throughout in darkness causes the development of weak, long, etiolated sprouts which is detrimental for early emergence and resprouting does hasten early plant emergence. In Arran Pilot and Majestic the etiolated sprouts of 195.4 and 178.3 mm. respectively are as effective as those sprouted in light, 35.7 mm. and 17.1 mm. respectively as regards early plant emergence, and etiolated sprouts above that length cause a slower rate of plant emergence.

C. DISCUSSION

EXPERIMENT 3

The numbers of sprouts per tuber which developed during the storage period were found to increase following the previous removal of sprouts. Thus tubers desprouted after 123 and 137 days of sprouting in darkness subsequently formed a greater number of sprouts per tuber (irrespective of whether resprouting was carried out in light or darkness) than those sprouted throughout the storage period with the first sprouts intact. Larger number of sprouts per tuber associated with the desprouting treatments was partly due to the increased number of sprouted eyes per tuber and partly to the greater number of sprouts per eye. Appleman (1918, 1925) reported that if the first formed sprouts are removed or for any reason retarded in their normal growth, sprouts will appear from the other eyes, and similarly when the dominant sprout in an eye is destroyed or retarded in growth other buds in the eye become active and produce sprouts. Later Bushnell (1929), Toosey (1959) and Hiele (1961) indicated that removal of sprouts resulted in a loss of apical dominance and that the number of sprouts subsequently formed was greater than that of comparable tubers where the first formed sprouts remained intact.

In the present observation it was found that tubers with one or two apical eyes removed and sprouted throughout the storage period did not give a greater number of sprouts (average for variety) than comparable tubers sprouted with apical eyes intact. As the connection between other apical and basal eyes still remained, it appeared that sprouting from the other regions of the tuber was suppressed due to the dominant effect of sprouts produced from remaining eyes at the rose end.

In comparing sprouting in light and darkness (averaged for variety) tubers sprouted in light gave a greater number of sprouts per tuber than those sprouted in darkness but the increase was only significant in the case of tubers sprouted throughout after removal of apical eyes.

In both varieties tubers desprouted at the time of planting produced plants above ground significantly later than those planted with sprouts intact, as has been shown by earlier authors (McCubbin 1941, Filimanov and Rustshkina 1934).

Tubers sprouted throughout in darkness having very long and etiolated sprouts (696.7 mm. in Arran Pilot and 407.1 mm. in Majestic) failed to show any advantage in early plant emergence over comparable tubers sprouted in light (35.7 mm. in Arran Pilot and 17.1 mm. in Majestic). However, during the course of the present investigation it has been noted that tubers desprouted after 137 days and resprouted in darkness giving etiolated sprouts (195.4 mm. in Arran Pilot and 178.3 mm. in Majestic) produced plants above ground earlier than comparable tubers sprouted in light having shorter and sturdier sprouts (14.6 mm. in

Arran Pilot and 13.3 mm. in Majestic). It seems that when the period of sprouting before planting is short, sprouting in darkness may hasten plant emergence due to the greater length of sprouts produced.

D. CONCLUSIONS

EXPERIMENT 3

In Experiment 3 studies were carried out on the effect of desprouting (after varying periods of storage) on sprouting in light or darkness and on plant emergence in Arran Pilot and Majestic.

1. Removal of sprouts and resprouting in light or darkness resulted in an increase in sprout number per tuber compared with tubers sprouted throughout the storage period in light or darkness with the first sprouts intact. Increase in sprout number associated with removal of sprouts was partly due to the increased number of sprouted eyes and partly to the number of sprouts per eye.

2. Removal of one or two apical eyes and sprouting throughout the storage period did not result in an increase in sprout number over comparable tubers sprouted with apical eyes intact.

3. Removal of sprouts at the time of planting caused a slower rate of plant emergence.

4. Delay in desprouting and resprouting in light resulted in a slow rate of plant emergence, whereas delay in desprouting and resprouting in darkness resulted in earlier plant emergence.

5. Tubers desprouted after 137 days of storage (October

to March) and resprouted in darkness until planting time (first week of May) having etiolated sprout (195.4 mm. sprout length in Arran Pilot and 178.3 mm. in Majestic) produced plants above ground earlier than comparable tubers resprouted in light (14.6 mm. sprout length in Arran Pilot and 13.3 mm. in Majestic) and as early as those sprouted throughout in light (35.7 mm. sprout length in Arran Pilot and 17.1 mm. in Majestic).

PART 2

E X P E R I M E N T S

(1960-61)

Experiment 4. Effect of varying periods of storage at different temperatures and with or without T.C.N.B. on subsequent sprouting behaviour and plant development of seed potatoes

A. Materials and Methods

Certified (Scottish Grade A) seed tubers of Arran Pilot and Majestic were obtained on 4th November and graded by weight into two size categories, (a) small, ranging from 80-100 gm., and (b) large, ranging from 120-140 gm. Eighteen samples of 70 tubers of each size of each variety were then separated out and weighed and placed in lidded cardboard boxes (18" x 12" x 9") so that each box contained a sample of large or small tubers of one variety with a partition separating the two sizes. Out of each 70 tubers sample, 10 tubers were numbered 1 to 10 for the study of sprouting behaviour during storage. Five tubers added to each sample were weighed separately and marked for the study of sprout growth in weight after sprouting in light.

Of the 18 boxes of each variety, each containing 75 weighed tubers of each size, tubers of 9 boxes of each variety were dusted with 80.35 gms. of Fusarex (3% Tetra-Chloronitrobenzene) on 7th November. The tubers of the remaining boxes were left untreated. Three boxes of dusted tubers and three of undusted tubers of each variety were then stored at high temperature (65°-80°F), three at medium (50°-60°F) and three at low temperature respectively.

With regard to low temperature storage, Fusarex treated tubers were stored in a farm building where the temperature ranged from 35.7°F (Minimum) to 49.7°F (Maximum) and the untreated tubers were stored in a cold room held at 40°F. In the subsequent discussion the temperature of the farm building (T.C.N.B. treatment) may be regarded as the same as that of the cold room (40°F). Mean monthly temperatures of the high and medium temperature storage room and of the farm building (low temperature) are shown in Appendix 38.

On 4th January, i.e. 8 weeks (or 58 days) after the beginning of the experiment, one box of treated and one box of untreated tubers of each variety held at the various temperatures were taken out of storage. Samples of tubers which had sprouted, i.e. all samples held at medium or high temperatures, were then desprouted and the fresh weights of the 70 tubers and their sprouts were taken. The five additional tubers to each sample were also desprouted. Weights of tuber samples held at low temperature, none of which showed sprouting, were taken directly. All the samples were then transferred to trays for sprouting in light.

Sprouting from 4th January to 14th February was carried out in natural daylight in the medium temperature storage room where the temperature ranged from 50°F (Minimum) to 57.2°F (Maximum) [Appendix 38]. The trays were then transferred to a cooler farm building, lit by fluorescent lighting, where the temperature ranged from

37.7°F (Minimum) to 49.7°F (Maximum) [Appendix 38].

On 20th February, i.e. 105 days after the start of the experiment, a similar procedure was adopted on further samples of tubers removed from storage and placed in trays for sprouting in light. The trays were held in natural daylight in the medium temperature storage until 4th April (temperature ranged from 50.5°F Minimum to 58.5°F Maximum) when they were transferred to the cooler farm building under fluorescent lighting until planting.

The remaining boxes of tubers were held in storage until the time of planting when tubers held at medium and high temperature were desprouted and the fresh weight of tubers and sprouts recorded. Arran Pilot tubers held at low temperature (40°F) without T.C.N.B., which also showed some sprout development, were desprouted and the weight of tubers and sprouts noted, whereas those stored with T.C.N.B. and also Majestic tubers irrespective of T.C.N.B. treatment had not sprouted and their fresh weight was recorded directly. The various treatments of the Experiment 4 are summarised in Table 51. Appendix 39 presents the initial fresh weight (gm.) of the 70 tubers and of tubers and sprouts at the time of desprouting for all samples.

Observations on Tubers Sprouted in Light

The following observations were recorded at the end of the sprouting period in light (11th April).

(i) Number of sprouts per tuber taking into account

TABLE 51

Summary of Treatments of Experiment 4

Length of period of storage (days) with or without T.C.N.B. at different temperature			Date of Sprouting in Light	Length of Period of Sprouting (days)
High (65°-80°F)	Medium (50°-60°F)	Low (40°F)		
58 days	58 days	58 days	4. 1.61	98 days
105 "	105 "	105 "	20. 2.61	51 "
158 "	158 "	158 "	-	-

the number of sprouts per eye and the number of sprouted eyes per tuber.

(ii) Lengths of sprouts (10 tuber samples).

(iii) Fresh weight of sprouts (5 tuber samples).

FIELD STUDIES

I. Large Scale Studies: Plant Emergence, Aerial Stem Development and Yield at Maturity

Planting

Tubers from the various storage treatments were planted on 28th April in 27" drills at 18" spacing.

Treatment and Layout

The experimental layout contained the combination of the following factors:

(a) Variety - (i) Arran Pilot and (ii) Majestic.

(b) (i) Date of desprouting - (1) 1st desprouting on 4th February, 1961

(2) 2nd desprouting on 20th February, 1961

(3) 3rd desprouting at the time of planting.

(ii) Seed size - (1) Large seed (120-140 gms.)

(2) Small seed (80-100 gms.)

(c) Treatment - (1) Tubers stored at 65°-80°F without T.C.N.B.

(2) Tubers stored at 50°-60°F without T.C.N.B.

(3) Tubers stored at 40°F without T.C.N.B.

(4) Tubers stored at 65°-80°F with T.C.N.B.

(5) Tubers stored at 50°-60°F with T.C.N.B.

(6) Tubers stored at 40°F with T.C.N.B.

The experiment was of split split plot in a randomised

Fig.8 LAY OUT OF THE EXPERIMENT 4 FOR YIELD TRIAL

	R1 ARRAN PILOT		R2 MAJESTIC		R3 ARRAN PILOT		R4 MAJESTIC		
19½ FT	D_3S_1	D_2S_2	D_1S_2	D_2S_1	D_1S_1	D_3S_1	D_3S_1	D_2S_2	57 FT
18 FT	D_1S_1	D_1S_2	D_3S_2	D_2S_2	D_2S_2	D_1S_2	D_1S_2	D_1S_1	
19½ FT	D_3S_2	D_2S_1	D_1S_1	D_3S_1	D_2S_1	D_3S_2	D_2S_1	D_3S_2	

3 FT PATH

19½ FT	D_3S_1	D_1S_1	D_2S_2	D_3S_1	D_1S_2	D_3S_1	D_2S_2	D_1S_1	57 FT
18 FT	D_2S_1	D_3S_2	D_1S_2	D_3S_2	D_2S_1	D_1S_1	D_2S_1	D_3S_2	
19½ FT	D_2S_2	D_1S_2	D_1S_1	D_2S_1	D_3S_2	D_2S_2	D_1S_2	D_3S_1	
	MAJESTIC 20 DRILLS		ARRAN PILOT 19 DRILLS		MAJESTIC 19 DRILLS		ARRAN PILOT 20 DRILLS		

D_1 - DESPROUTED ON 4.1.61
D_2 - " " 20.2.61
D_3 - " AT THE TIME OF PLANTING

S_1 - LARGE SEED
S_2 - SMALL SEED

block system. There were four replications. Each replication was divided into two main plots for the two varieties. Each main plot was then divided into six sub plots for date of desprouting and seed size combination (i.e. 3 x 2) randomised in each main plot. Each sub plot was divided into six sub sub plots and the six treatments (temperature x chemical treatment) were randomised giving 2 x 3 x 2 x 6, i.e. 72 sub sub plots in each replicate (Fig. 8).

The main plots of each replication were separated by a path 3 ft. wide and on either side of the path two discard hills were planted at the end of each row. One discard hill per row was planted at each end of each replication. In each treatment (sub sub plot) 10 tubers were planted in two rows of five tubers each. Each treatment along a row was followed by a discard hill of Kerr's Pink and two treatment rows were followed by a discard row of Majestic in the case of Arran Pilot main plots and Arran Pilot in the case of Majestic main plots.

Each replication was separated by two discard drills and there were two guard rows at both sides. Each replication consisted of 12 treated and 7 discard drills. Thus there were 48 treated and 30 discard drills in the layout and the area covered was 173.25' x 117.0' or 0.46 acre.

Field Cultivation after Planting

The experimental plot was harrowed on 9th May. Inter-row cultivation was done on 2nd June and drills were ridged up again on 8th June.

For the control of blight a spray of Perenox was applied on 24th June and a second spray was applied on 22nd August. Throughout the growing period plants remained free from infection.

The weather conditions during the growing period are summarised in Appendix 40. From May to June rainfall was below average with above average temperature and hours of sunshine, and from July to August rainfall was above average with near average temperatures and sunshine.

Field Observation and Collection of Data

(a) Rate of Plant Emergence. Counts of plant emergence were made twice per week from 9th May. As soon as the sprouts broke through the ground with one expanded leaf they were counted. These observations were carried out until the drills were ridged up again on 8th June, i.e. 41 days after planting.

(b) Number of Aerial Stems. Numbers of aerial stems, i.e. main stem plus underground branches from the main stem, were counted on 17th June.

(c) Yield and Grading. The crops were lifted from 2nd to 9th October, i.e. 158 to 165 days after planting, by which time all plants showed leaf senescence. The total weights and weight of commercial grades, viz. ware (over $2\frac{1}{4}$") and seed ($2\frac{1}{4}$" - $1\frac{1}{4}$"), were recorded for every sub sub plot.

At the time of grading the total number of tubers as well as the numbers of ware and seed were noted.

Statistical Analysis and Method of the Presentation of Data

The data of the large scale experiment relating to rate of plant emergence, number of aerial stems, total yield in weight and number of tubers, yield in weight and number of ware and seed, were subjected to the "Analysis of Variance" appropriate to the designs. There were three estimates of error applicable to (a) effect of varieties, (b) effect of time of desprouting and seed size and their interaction and their interaction with varieties, (c) the effect of storage treatments and their interaction with variety, date of desprouting and seed sizes.

The methods of statistical analysis were based on those of Yates (1937) and Paterson (1939).

The other information is recorded in the form of two way or three way tables on the basis of the statistical analysis with the appropriate standard error. The difference is considered significant whenever the difference is greater than $\sqrt{2}$ x S.E. x t (Fisher and Yates 1949).

II. Small Scale Plant Growth Studies

A small scale experiment using the same treated material was also planted out for plant growth studies.

Tubers were planted on 5th May in 27" drill at 18" spacing. The area covered by the experimental plot was

Fig.9 LAY OUT OF THE EXPERIMENT 4 FOR PLANT GROWTH STUDIES

Dimension							Sampling	Replicate
7½ FT	AD_3S_1	AD_2S_2	AD_1S_1	MD_2S_1	MD_1S_2	MD_3S_2	L_1	R_1
	AD_1S_2	AD_3S_2	AD_2S_1	MD_1S_1	MD_2S_2	MD_3S_1		
	AD_2S_2	AD_1S_1	AD_3S_2	MD_3S_2	MD_1S_1	MD_1S_2	L_3	
	AD_3S_1	AD_1S_2	AD_2S_1	MD_2S_1	MD_3S_1	MD_2S_2		
30 FT	AD_2S_1	AD_1S_1	AD_3S_2	MD_2S_2	MD_1S_2	MD_2S_1	L_4	
	AD_1S_2	AD_2S_2	AD_3S_1	MD_3S_1	MD_3S_2	MD_1S_1		
	AD_1S_1	AD_3S_2	AD_1S_2	MD_2S_2	MD_2S_1	MD_3S_2	L_2	
	AD_2S_1	AD_3S_1	AD_2S_2	MD_1S_1	MD_3S_1	MD_1S_2		
	MD_1S_2	MD_3S_2	MD_1S_1	AD_3S_2	AD_2S_2	AD_2S_1	L_1	R_2
	MD_3S_1	MD_2S_2	MD_2S_1	AD_1S_1	AD_1S_2	AD_3S_1		
	MD_2S_1	MD_1S_1	MD_3S_2	AD_2S_2	AD_3S_1	AD_1S_2	L_3	
	MD_2S_2	MD_1S_2	MD_3S_1	AD_1S_1	AD_3S_2	AD_2S_1		
30 FT	MD_1S_1	MD_2S_1	MD_1S_2	AD_1S_2	AD_1S_1	AD_2S_2	L_2	
	MD_3S_2	MD_3S_1	MD_2S_2	AD_2S_1	AD_3S_2	AD_3S_1		
	MD_1S_2	MD_2S_2	MD_1S_1	AD_3S_1	AD_1S_1	AD_3S_2	L_4	
	MD_2S_1	MD_3S_1	MD_3S_2	AD_1S_2	AD_2S_2	AD_2S_1		
	AD_1S_1	AD_2S_1	AD_1S_2	MD_3S_1	MD_2S_2	MD_1S_1	L_2	R_3
	AD_3S_2	AD_3S_1	AD_2S_2	MD_1S_2	MD_2S_1	MD_3S_2		
	AD_1S_1	AD_1S_2	AD_3S_1	MD_2S_1	MD_3S_2	MD_2S_2	L_3	
	AD_2S_2	AD_2S_1	AD_3S_2	MD_1S_2	MD_1S_1	MD_3S_1		
30 FT	AD_2S_1	AD_2S_2	AD_1S_1	MD_1S_1	MD_1S_2	MD_2S_2	L_4	
	AD_1S_2	AD_3S_2	AD_3S_1	MD_3S_2	MD_3S_1	MD_2S_1		
	AD_3S_2	AD_1S_1	AD_2S_2	MD_2S_2	MD_1S_1	MD_1S_2	L_1	
	AD_3S_1	AD_1S_2	AD_2S_1	MD_3S_1	MD_3S_2	MD_2S_1		
	4 DRILLS	3 DRILLS	3 DRILLS	3 DRILLS	3 DRILLS	4 DRILLS		
	10 DRILLS			10 DRILLS				

A - ARRAN PILOT

M - MAJESTIC

D_1 - DESPROUTED ON 4.1.61

D_2 - " " 20.2.61

D_3 - " AT THE TIME OF PLANTING

S_1 - LARGE SEED

S_2 - SMALL SEED

L_1 - 1st. SAMPLING ON 29.6.61

L_2 - 2nd " " 20.7.61

L_3 - 3rd. " " 9.8.61

L_4 - 4th " " 31.8.61

90' x 45' or 0.09 acre.

The time of field cultivation after planting and fungicidal spray was the same as that for the large scale trial.

The experimental layout is shown in Fig. 9. There were three replicates. Each replicate was divided into four equal blocks for four dates of sampling. Each block was then divided into two sub blocks for two varieties. Each sub block was then divided into six sub sub blocks and date of desprouting and seed size combinations were randomised. In each sub sub block one tuber from each treatment, i.e. six tubers from six treatments, were planted at random. In this layout there was no discard hill or discard row between the treatments. However, there was a discard hill in each row between the blocks. Single discards were at the end of each row and along the rows at each side of the whole experimental plot.

At the time of sampling, one block from each replication was selected at random. Thus three plants were lifted in each sampling in each treatment.

Observation and Collection of Data

Samples were taken from the field at an interval of three weeks on 29th June (56 days after planting); 20th July (77 days after planting); 9th August (98 days after planting) and 31st August (119 days after planting).

During each sampling the plants were brought into the laboratory, washed free of soil and the following observations were carried out - (1) the number of main stems and underground branches from main stem, (2) the number and size (diameter in cm.) of tubers, (3) dry weight of foliage, and (4) dry weight of tubers.

For dry weight determination the three plants of each treatment were dried together in an electric oven at 95^{o}-$100^{o}C$ for 24 hours.

The data on number of stems, tubers and dry weight of foliage and tubers were represented as the mean of three plants.

RESULTS

B. Studies During Storage Period

1. Effect of Different Storage Treatments on Loss in Weight of Tuber before Sprouting in Light

The actual loss in weight (gm.) due to (a) sprouting and (b) transpiration and respiration of each 70 tuber sample during the storage period in boxes for the various storage treatments is given in Appendix 41. These losses, expressed as a percentage of the initial tuber weight, are presented in Appendix 42.

Variations in weight loss between different samples may be related to seed size, variety, time of desprouting and storage conditions as follows:-

(i) Size of Seed Tuber. The actual loss in weight (gm.) due to both sprouting and other losses (transpiration and respiration) was greater in large seed than in small seed of both varieties, averaged for the various times of desprouting and different storage conditions (Table 52). Losses in weight due to sprouting and other losses expressed as a percentage of the initial fresh weight of tubers in the two seed sizes were, however, similar (Table 53).

(ii) Variety. The loss in weight due to both sprouting or other losses was greater in Arran Pilot (a vigorous sprouting variety) than in Majestic (a slow sprouting variety) [Table 52 and 53].

TABLE 52

Effect of seed size and variety on weight loss in storage due to (a) sprouting and (b) transpiration and respiration

Gm. per 70 tuber sample
(Average for all storage treatments)

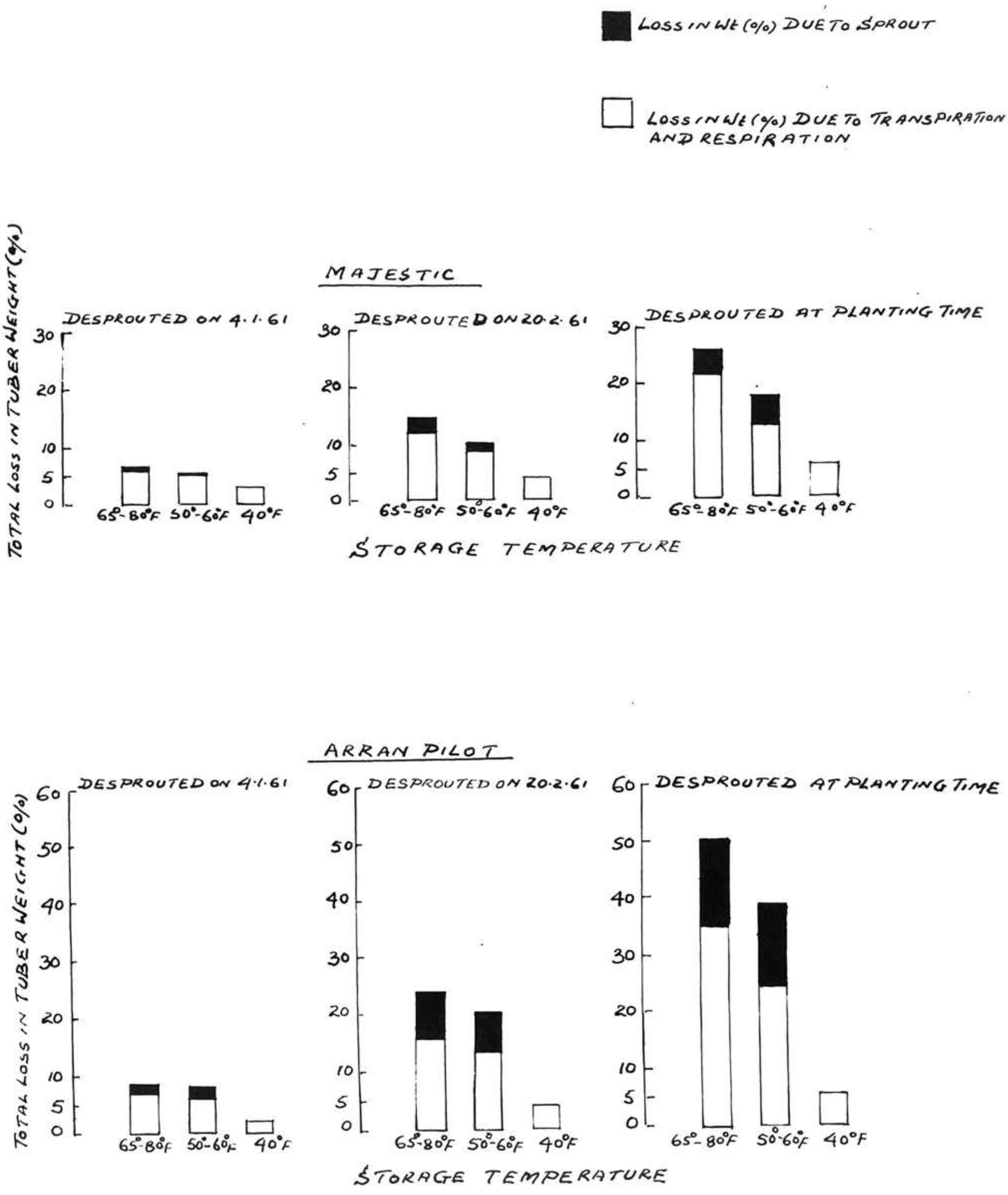
Variety	Loss in wt. (gm.) due to Sprouting		Loss in wt. (gm.) due to Transpiration and Respiration		Total loss in wt. (gm.)		Mean		
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Loss in wt. (gm.) due to Sprouting	Loss in wt. (gm.) due to Transpiration and Respiration	Total loss in wt. (gm.)
Arran Pilot	475.1	302.7	1149.8	750.1	1624.9	1052.8	388.9	949.9	1338.8
Majestic	141.9	99.9	856.8	583.4	998.7	683.3	120.9	720.1	841.0
Mean	308.5	201.3	1003.3	666.7	1311.8	868.0			

TABLE 53

Effect of seed size and variety on weight loss in storage due to (a) sprouting and (b) transpiration and respiration expressed as percentage of initial tuber weight (average for all storage treatments)

Variety	Loss in wt. (%) due to Sprouting		Loss in wt. (%) due to Transpiration and Respiration		Total loss in wt. (%)		Mean		
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Loss in wt. (%) due to Sprouting	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt. (%)
Arran Pilot	5.20	5.40	12.51	13.31	17.71	18.71	5.30	12.91	18.21
Majestic	1.48	1.54	8.97	9.09	10.45	10.63	1.50	9.03	10.54
Mean	3.34	3.47	10.74	11.20	14.08	14.67			

Fig.10 EFFECT OF DIFFERENT STORAGE TEMPERATURES ON TOTAL LOSS IN TUBER WEIGHT(o/o) AT THE TIME OF DESPROUTING.



(iii) <u>Treatment</u>. To explain more clearly the effect of storage treatment and its interaction with variety and date of desprouting on loss in weight of tubers, the effects of treatments are considered in three parts, viz. (a) effect of temperature, (b) effect of chemical sprout inhibition, and (c) interaction of temperature and chemical sprout inhibition. Weight losses are expressed as a percentage of initial fresh weight of tubers and the average of the two seed sizes are taken.

(a) <u>Effect of Temperature of Storage</u>

Increase in temperature of storage above 40°F greatly increased the loss in weight of tubers due to sprouting (Table 54) and other losses (transpiration and respiration) [Table 55]. In the case of sprout losses, the differences between high (65°-80°F) and medium (50°-60°F) temperature were only slight but were more marked with respect to other losses. Thus the total loss in weight suffered by the mother tuber was maximum at 65°-80°F, slightly less at 50°-60°F and lowest at low temperature (Table 56, Fig. 10).

Losses attributable to transpiration and respiration were generally greater than those due to sprouting ranging from 2.28 to 35.42% in the former, compared with 0% to 15.06% for sprouting (Table 54 and 55). At low temperature loss in weight of tubers was due to transpiration and respiration only except in the case of Arran Pilot stored

TABLE 54

Effect of storage temperature and period of storage on percentage loss in tuber weight due to sprouting

Storage Temperature	Arran Pilot				Majestic			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65°-80°F)	1.29	8.16	15.06	8.17	0.27	2.40	4.56	2.41
Medium (50°-60°F)	1.78	7.27	14.07	7.71	0.07	1.33	4.90	2.10
Low (40°F)	-	-	0.03	0.01	-	-	-	-
Mean	1.02	5.14	9.72		0.11	1.25	3.15	

TABLE 55

Effect of storage temperature and period of storage on percentage loss in tuber weight due to transpiration and respiration

Storage Temperature	Arran Pilot				Majestic			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65°-80°F)	7.41	16.40	35.42	19.74	6.16	12.10	21.87	13.38
Medium (50°-60°F)	6.29	13.57	24.89	14.92	5.70	8.69	13.27	9.22
Low (40°F)	2.28	4.17	5.76	4.07	3.13	4.14	6.17	4.48
Mean	5.33	11.38	22.03		4.99	8.31	13.77	

TABLE 56

Effect of storage temperature and period of storage on total percentage loss in tuber weight

Storage Temperature	Arran Pilot				Majestic			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65^o-80^oF)	8.70	24.56	50.48	27.91	6.43	14.50	26.43	15.79
Medium (50^o-60^oF)	8.07	20.84	38.96	22.62	5.77	10.02	18.18	11.32
Low (40^oF)	2.28	4.17	5.80	4.08	3.13	4.14	6.17	4.48
Mean	6.35	16.52	31.74		5.11	9.55	16.92	

N.B. d_1 = desprouted on 4. 1.61

d_2 = desprouted on 20.2.61

d_3 = desprouted at the time of planting.

over a prolonged period (Table 54) where sprouting was noted. The effects of temperature on weight loss were magnified with increase in the length of the storage period and showed up greatest in Arran Pilot.

(b) Effect of Treatment with Sprout Inhibiting Chemical (T.C.N.B.)

Treatment with T.C.N.B. suppressed the growth of sprouts (Table 57) and thereby reduced the total weight loss in storage (Table 59 and Fig. 11). Losses due to transpiration and respiration were, however, more or less

Fig.11 EFFECT OF T.C.N.B. TREATMENT ON TOTAL LOSS IN TUBER WEIGHT (o/o) AT THE TIME OF DESPROUTING

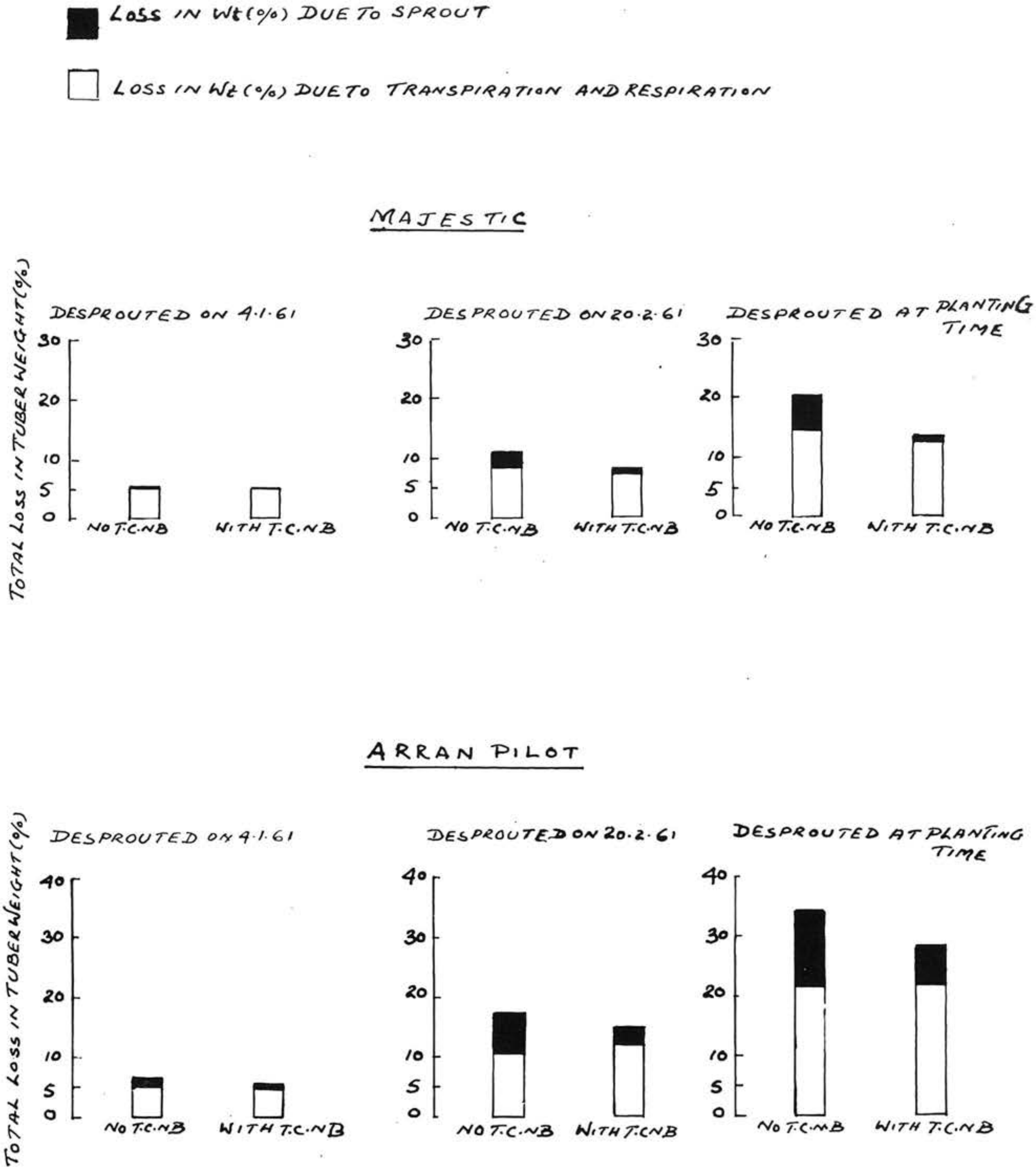
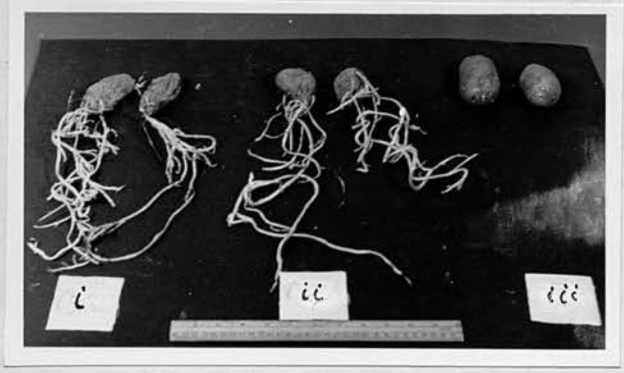


PLATE 1

EXPERIMENT 4 (1960-61)

SHOWING THE SPROUTING CONDITION OF SEED TUBERS (LARGE AND SMALL) OF ARRAN PILOT AND MAJESTIC AT PLANTING TIME, STORED THROUGHOUT AT 65°-80°F, 50°-60°F and 40°F WITH OR WITHOUT T.C.N.B.

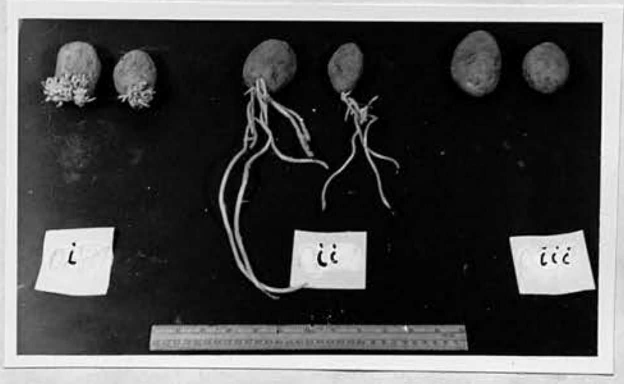


A. ARRAN PILOT

(i) STORED AT 65°-80°F WITHOUT T.C.N.B.

(ii) STORED AT 50°-60°F WITHOUT T.C.N.B.

(iii) STORED AT 40°F WITHOUT T.C.N.B.

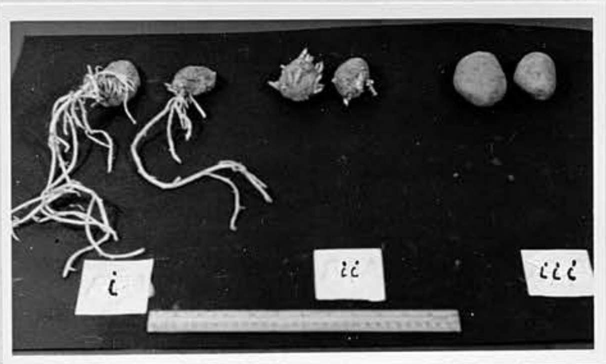


B. MAJESTIC

(i) STORED AT 65°-80°F WITHOUT T.C.N.B.

(ii) STORED AT 50°-60°F WITHOUT T.C.N.B.

(iii) STORED AT 40°F WITHOUT T.C.N.B.



C. ARRAN PILOT

(i) STORED AT 65°-80°F WITH T.C.N.B.

(ii) STORED AT 50°-60°F WITH T.C.N.B.

(iii) STORED AT 40°F WITH T.C.N.B.

D. MAJESTIC

(i) STORED AT 65°-80°F WITH T.C.N.B.

(ii) STORED AT 50°-60°F WITH T.C.N.B.

(iii) STORED AT 40°F WITH T.C.N.B.

Fig.12 EFFECT OF T.C.N.B. TREATMENT AT DIFFERENT TEMPERATURES ON TOTAL LOSS IN TUBER WEIGHT (o/o) AT THE TIME OF DESPROUTING.

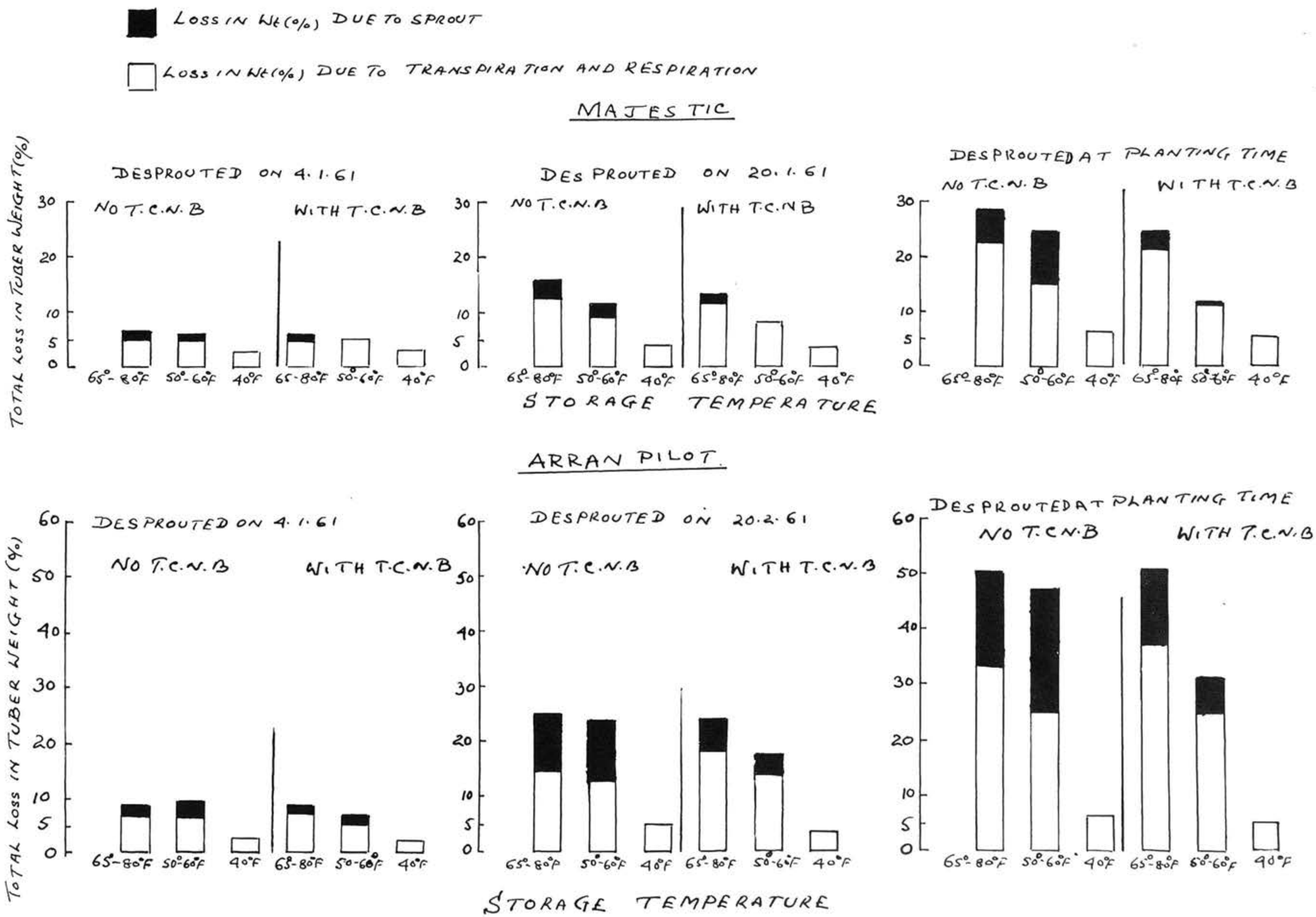


TABLE 57

Effect of storage treatment on percentage loss in tuber weight due to sprouting

Storage Temperature	Arran Pilot								Majestic							
	Without T.C.N.B.				With T.C.N.B.				Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65^o-80^oF)	1.51	10.39	16.62	9.51	1.07	5.94	13.50	6.84	0.34	3.29	5.82	3.15	0.21	1.52	3.30	1.68
Medium (50^o-60^oF)	2.94	11.22	21.98	12.05	0.62	3.32	6.16	3.37	0.14	2.67	9.65	4.15	-	-	0.16	0.05
Low (40^oF)	-	-	0.07	0.02	-	-	-	-	-	-	-	-	-	-	-	-
Mean	1.48	7.20	12.89	7.19	0.56	3.09	6.55	3.40	0.16	1.99	5.16	2.44	0.07	0.51	1.15	0.58

N.B. d_1 = desprouted on 4.1.61
d_2 = desprouted on 20.2.61
d_3 = desprouted at the time of planting

similar between dusted and untreated tubers (Table 58 and Fig. 11).

(c) Interaction of Temperature and Treatments with T.C.N.B.

While storage at medium and high temperatures gave rise to appreciable sprouting in contrast to storage at low temperature, in all instances it may be noted from Table 57 and Fig. 12 that the response to medium compared with high temperature varied according to whether tubers had been dusted with T.C.N.B. or not. Untreated tubers stored at medium temperature produced on average more sprout growth than those stored at high temperature. This effect was evident in both varieties stored until planting (Plates 1 A and B) but showed only as a slight trend in Arran Pilot for the earlier desprouting treatments (Fig. 12). Where tubers were treated with T.C.N.B., however, sprouting was less at medium temperature than at high temperature (Plates 1 C and D).

Losses in weight due to transpiration and respiration were in all cases increased with increase in storage temperature, irrespective of treatment with or without T.C.N.B. (Table 58). As other losses (transpiration and respiration) in both varieties formed the main source of loss, the total loss in weight also increased directly with an increase in storage temperature, but the difference between medium and high temperature was greater in tubers treated with T.C.N.B. (Table 59 and Fig. 12).

TABLE 58

Effect of storage treatments on percentage loss in tuber weight due to transpiration and respiration

Storage Temperature	Arran Pilot								Majestic							
	Without T.C.N.B.				With T.C.N.B.				Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65°-80°F)	7.17	14.67	33.42	18.42	7.66	18.13	37.43	21.07	6.17	12.69	22.70	13.85	6.15	11.51	21.05	12.90
Medium (50°-60°F)	6.53	12.77	25.13	14.81	6.06	14.37	24.65	15.03	6.04	9.28	15.20	10.17	5.36	8.10	11.35	8.27
Low (40°F)	2.54	4.58	6.33	4.48	2.03	3.77	5.20	3.67	2.84	4.41	6.65	4.63	3.42	3.88	5.70	4.33
Mean	5.41	10.67	21.63	12.57	5.25	12.09	22.43	13.26	5.02	8.79	14.85	9.55	4.98	7.83	12.70	8.50

d_1 = Desprouted on 4.1.61

d_2 = Desprouted on 20.2.61

d_3 = Desprouted at the time of planting.

TABLE 59

Effect of storage treatments on total percentage loss in tuber weight

Storage Temperature	Arran Pilot								Majestic							
	Without T.C.N.B.				With T.C.N.B.				Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65^o-80^oF)	8.68	25.06	50.04	27.93	8.73	24.07	50.93	27.91	6.51	15.98	28.52	17.00	6.36	13.03	24.35	14.58
Medium (50^o-60^oF)	9.47	23.99	47.11	26.86	6.68	17.69	30.81	18.39	6.18	11.95	24.85	14.33	5.36	8.10	11.51	8.32
Low (40^oF)	2.54	4.58	6.40	4.51	2.03	3.77	5.20	3.67	2.84	4.41	6.65	4.63	3.42	3.88	5.70	4.33
Mean	6.90	17.88	34.52	19.77	5.81	15.17	28.98	16.65	5.18	10.78	20.01	11.99	5.05	8.34	13.85	9.08

d_1 = Desprouted on 4.1.61

d_2 = Desprouted on 20.2.61

d_3 = Desprouted at the time of planting.

2. Growth of Sprouts in Terms of Fresh Weight (gm.) after Desprouting

The growth of sprouts in terms of fresh weight (per five tuber samples) formed during the period of sprouting in light in the various samples desprouted on 4th January or 20th February after previous storage at varying temperatures with or without T.C.N.B. are shown in Appendix 43.

Variations in fresh weight of sprout between different samples may be related to seed size, variety and previous storage conditions.

(i) Seed Size. The fresh weight of sprouts formed after sprouting in light varied with the size of seed tuber of both varieties, averaged for the various conditions of storage before sprouting. Thus large seed produced a greater amount of sprout growth than small seed, irrespective of time of desprouting (Table 60).

(ii) Variety. It can also be seen from Table 60 that in storage Arran Pilot, the more vigorous sprouting variety, continued to produce a greater weight of sprouts after desprouting than Majestic.

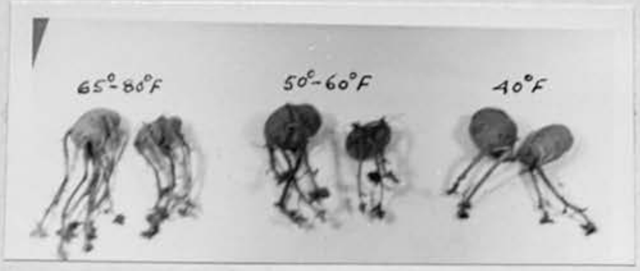
(iii) Previous Storage Treatment. In tubers stored without T.C.N.B. previous storage at low temperature gave a smaller amount of sprout growth in light than storage at medium and high temperature (Table 61) but the

PLATE 2

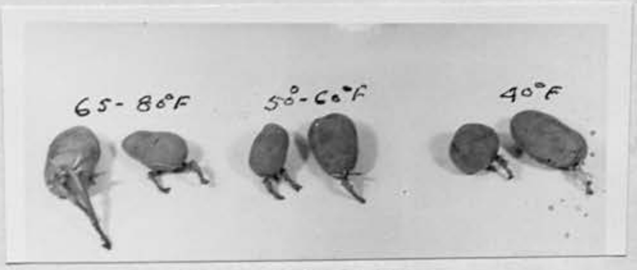
EXPERIMENT 4 (1960-61)

SHOWING THE SPROUTING CONDITION OF SEED TUBERS (LARGE AND SMALL) OF ARRAN PILOT AND MAJESTIC AT PLANTING TIME AS INFLUENCED BY DIFFERENT STORAGE TREATMENTS

SEEDS STORED AT 65°-80°F; 50°-60°F and 40°F
WITHOUT T.C.N.B. UNTIL 4.1.61



A. ARRAN PILOT



B. MAJESTIC

SEEDS STORED AT 65°-80°F; 50°-60°F and 40°F
WITHOUT T.C.N.B. UNTIL 20.2.61

C. ARRAN PILOT

D. MAJESTIC

TABLE 60

Effect of seed size and variety on growth of sprouts in light. Fresh weight (gm.) per five tuber samples (average for all storage treatments)

Variety	Wt. (gm.) of sprouts at the time of planting sprouted in light at different dates of storage						Mean
	d_1			d_2			
	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	
Arran Pilot	48.87	36.60	42.73	12.45	11.12	11.78	27.25
Majestic	14.12	11.07	12.59	7.81	4.88	6.34	9.46
Mean	31.49	23.83	27.66	10.13	8.0	9.06	

N.B. d_1 = desprouted on 4.1.61; d_2 = desprouted on 20.2.61

differences between medium and high temperature were less consistent. At the first desprouting (d_1) previous storage at high temperature resulted in a greater amount of sprout formation than medium temperature in both varieties (Plates 2 A and B) but for the prolonged period of storage (d_2) before desprouting there was little effect of the two temperature levels (Plates 2 C and D) and medium temperature tended to give a higher growth of sprout in Majestic than high temperature (Table 61). It seems that with shorter periods of exposure to varying temperature, increase in temperature from 40°F - 80°F stimulated subsequent growth of sprouts, but over a longer

TABLE 61

Effect of different storage treatment on subsequent growth of sprouts in light (Fresh weight* of sprout per five tuber samples at the time of planting)

Storage Temperature	Arran Pilot						Majestic					
	Without T.C.N.B.			With T.C.N.B.			Without T.C.N.B.			With T.C.N.B.		
	d_1	d_2	Mean	d_1	d_2	Mean	d_1	d_2	Mean	d_1	d_2	Mean
High (65°-80°F)	65.80	14.67	40.23	45.87	5.15	25.51	21.20	6.65	13.92	22.20	6.90	14.55
Medium (50°-60°F)	44.40	13.72	29.06	48.75	15.11	31.93	10.65	12.90	11.77	8.80	1.60	5.20
Low (40°F)	23.15	10.79	16.97	28.42	11.27	19.84	7.00	4.57	5.78	5.80	5.45	5.62

N.B. d_1 = Desprouted on 4. 1.61

d_2 = Desprouted on 20. 2.61

* gm

PLATE 3

EXPERIMENT 4 (1960-61)

SHOWING THE SPROUTING CONDITION OF T.C.N.B. TREATED SEED TUBERS (LARGE AND SMALL) OF ARRAN PILOT AND MAJESTIC AT PLANTING TIME AS INFLUENCED BY DIFFERENT TEMPERATURE AND PERIOD OF STORAGE

ARRAN PILOT

A. STORED AT 65°-80°F, 50°-60°F AND 40°F UNTIL 4.1.61

B. STORED AT 65°-80°F, 50°-60°F AND 40°F UNTIL 20.2.61

MAJESTIC

C. STORED AT 65°-80°F, 50°-60°F AND 40°F UNTIL 4.1.61

D. STORED AT 65°-80°F, 50°-60°F AND 40°F UNTIL 20.2.61

period (d_2) high temperature may not give further response over medium temperature or may show an after effect in decreasing growth (Table 61).

Response to temperatures of previous storage in the case of tubers stored with T.C.N.B. differed with variety. In Arran Pilot tubers treated with T.C.N.B. the effect of previous storage temperature on subsequent growth in weight of sprouts varied according to the period of storage. Thus, for a short period of exposure (from 4th November to 4th January) the increase in temperature up to 50°-60°F gave increased sprouting, and above this there was no further response (Plate 3 A). Over a longer period (from 4th November to 20th February) previous storage at high temperature resulted in a smaller amount of sprout formation than storage at low temperature and the greatest sprout growth was obtained from medium temperature storage (Plate 3 B) [Table 61]. It can also be seen in Table 61 that in Arran Pilot no marked differences in weight of sprouts between T.C.N.B. and no T.C.N.B. treatment at medium and low temperature were found, irrespective of period of storage, whereas at high temperature previous treatment with T.C.N.B. resulted in a smaller amount of sprout formation than those stored without T.C.N.B. This result also indicates that in Arran Pilot, unless tubers are stored at high temperature, previous treatment with T.C.N.B. does not inhibit the subsequent growth of sprouts. In Majestic, increase in the temperature of storage when the period was short (from 4th November to 4th January, i.e. d_1) resulted in a greater subsequent growth of sprouts (Plate 3 C). With the longer period of exposure (from 4th November to 20th February) however, medium temperature in combination with T.C.N.B. had a depressing effect on subsequent growth of sprouts and many tubers failed to produce any sprouts during the period of sprouting in light (Table 61). As a result, the amount of sprout development was lowest in this treatment with little difference between the effects of high and low temperature (Plate 3 D). In comparing T.C.N.B. and no T.C.N.B. treatment in Majestic, for shorter period of storage (from 4th November to 4th January) little difference in growth in weight of sprouts was found between the two treatments, irrespective of temperature. When the storage period was prolonged (from 4th November to 20th February) T.C.N.B. at medium temperature resulted in less growth of sprouts than no T.C.N.B., although T.C.N.B. treatment had no apparent adverse effect at other storage temperatures (Table 61).

When times of desprouting were compared, it was noted that in Arran Pilot, irrespective of storage treatment, delay in desprouting and resprouting in light (d_2) resulted in a smaller amount of sprout growth. This sprouting behaviour, associated with period of storage before sprouting in light, was found in Majestic. However, in this variety tubers stored at medium temperature without T.C.N.B. until 4th January (d_1) did not give rise to a greater amount of sprout at planting time than those stored until 20th February (d_2) before desprouting (Table 61).

TABLE 62

Effect of seed size and variety on number of sprouts per tuber in different length categories at the time of planting

Variety	No. of sprouts in different length categories at the time of planting, sprouted in light during varying dates of storage															
	d_1								d_2							
	Large Seed				Small Seed				Large Seed				Small Seed			
	1-10 mm.	11-30 mm.	31-60 mm.	61 mm. and over	1-10 mm.	11-30 mm.	31-60 mm.	61 mm. and over	1-10 mm.	11-30 mm.	31-60 mm.	61 mm. and over	1-10 mm.	11-30 mm.	31-60 mm.	61 mm. and over
Arran Pilot	6.8	1.1	0.6	3.3	6.5	0.7	0.3	2.7	8.9	4.3	1.1	0.2	6.7	3.1	1.0	0.1
Majestic	4.4	1.6	0.7	0.1	3.8	1.2	0.7	0.1	5.6	2.4	1.1	-	4.9	2.2	0.1	-
Mean	5.6	1.3	0.6	1.7	5.1	0.9	0.5	1.4	7.2	3.3	1.1	0.1	5.8	2.6	0.5	0.05

d_1 = Desprouted on 4. 1.61

d_2 = Desprouted on 20. 2.61

3. Number of Sprouts per Tuber in Different Length Categories

The effect of seed size, variety and time of desprouting on the growth of sprouts in terms of fresh weight is also reflected in the data on numbers of sprouts per tuber in different length categories. The number of sprouts per tuber in different length categories formed during the period of sprouting in light in the various samples desprouted on 4th January or 20th February after previous storage at varying temperatures with or without T.C.N.B. are shown in Appendix 44.

Large seed tended to produce more sprouts per tuber than small seed and this applied on average to numbers in all length categories (Table 62). With respect to varietal differences, the number of sprouts per tuber was generally greater in Arran Pilot than in Majestic and sprouts were found to be much longer in the former variety for comparable times of desprouting (Table 62). In all treatments desprouted on 4th January (d_1) and occasionally in treatments desprouted on 20th February (d_2) sprouts longer than 60 mm. were produced by Arran Pilot (Table 63) whereas lengths above 60 mm. were exceptional in Majestic (Table 64).

In Arran Pilot tubers desprouted on 4th January (d_1) before sprouting in light after previous storage at low temperature gave fewer excessively long sprouts, i.e. above 60 mm., compared with those stored at medium and high

TABLE 63

Effect of previous treatment on the length of sprouts per tuber at the end of the sprouting period in light in Arran Pilot

Storage Treatment	Arran Pilot									
	Size Group in mm.									
	d_1					d_2				
	1-10	11-30	31-60	61-Over	Total no. of Sprout	1-10	11-30	31-60	61 - Over	Total no. of Sprout
Stored at 65°-80°F without T.C.N.B.	5.0	0.9	0.7	3.9	10.1	7.8	3.5	2.3	0.2	13.8
Stored at 50°-60°F without T.C.N.B.	5.9	0.8	0.2	2.7	9.6	7.4	5.6	0.5	0.1	13.6
Stored at 40°F without T.C.N.B.	7.8	0.7	0.8	1.3	10.6	8.5	3.4	0.8	0.05	12.7
Stored at 65°-80°F with T.C.N.B.	5.7	1.0	0.1	4.3	11.1	5.8	3.3	0.5	-	9.6
Stored at 50°-60°F with T.C.N.B.	5.6	1.3	0.5	4.2	11.6	4.3	2.7	1.5	0.4	8.9
Stored at 40°F with T.C.N.B.	9.6	0.8	0.5	1.6	12.5	13.0	3.4	0.6	-	17.0

d_1 = Desprouted on 4.1.61 d_2 = Desprouted on 20.2.61

TABLE 64

Effect of previous storage treatments on the length of sprouts per tuber at the end of the sprouting period in light in Majestic

Storage Treatment	Majestic									
	Size Group in mm.									
	d_1					d_2				
	1-10	11-30	31-60	61 - Over	Total no. of Sprout	1-10	11-30	31-60	61 - Over	Total no. of Sprout
Stored at 65°-80°F without T.C.N.B.	2.7	1.0	1.7	-	5.4	3.0	2.9	0.3	-	6.2
Stored at 50°-60°F without T.C.N.B.	3.5	1.3	0.5	-	5.3	2.6	2.8	0.9	0.05	6.3
Stored at 40°F without T.C.N.B.	7.4	1.5	0.2	-	9.1	10.5	2.4	-	-	12.9
Stored at 65°-80°F with T.C.N.B.	3.3	2.1	1.7	0.6	7.7	5.5	3.1	0.2	0.05	8.8
Stored at 50°-60°F with T.C.N.B.	0.9	0.8	0.2	-	1.9	0.7	0.2	-	-	0.9
Stored at 40°F with T.C.N.B.	6.5	1.7	0.05	-	8.2	9.0	2.4	-	-	11.4

d_1 = Desprouted on 4.1.61 d_2 = Desprouted on 20.2.61

temperature, but there was little difference between the two higher temperatures in their effect on frequency distribution of sprouts in different length categories (Table 63). This after-effect of low temperature in reducing sprout length applied to both T.C.N.B. treated and untreated tubers with no obvious effect exerted by T.C.N.B. at any temperature level. Where tubers were held over longer periods of storage (d_2) without T.C.N.B. before sprouting in light, low temperature storage again tended to reduce sprout lengths, giving fewer sprouts above 10 mm. than the two higher storage temperature treatments: in this instance high temperature gave fewer sprouts above 10 mm. than medium temperature (Table 63). In the case of T.C.N.B. treatment over a longer period (d_2), previous storage at low temperature gave a greater total number of sprouts than the higher temperature treatments, but in comparing the number of sprouts above 10 mm. there was no difference in effect between high and low temperatures, but medium temperatures tended to produce more sprouts above 30 mm. (Table 63).

Majestic tubers previously stored without T.C.N.B. at low temperature, while giving a greater total number of sprouts than those stored at higher temperatures, tended to produce shorter sprouts, the majority being less than 10 mm. for either date of desprouting (Table 64). Both high and medium temperature storage gave some sprouts above 30 mm. but the effect of temperature within this range appeared to vary with time of desprouting or the length of period of storage. Thus in tubers desprouted on 4th January (d_1) high temperature tended to give more longer sprouts, i.e. between 31 and 60 mm., than medium temperature and these tubers also appeared to give more longer sprouts than those sprouted later (d_2) after storage at high temperature. However, over a longer period of storage (from 4th November to 20th February, i.e. d_2) tubers stored at medium temperature appeared to give more sprouts above 30 mm. than high temperature (Table 64). With regard to T.C.N.B. treatment in Majestic, storage with T.C.N.B. at medium temperature caused a marked suppression in subsequent sprout growth. Comparing high and low temperature storage, low temperature gave more sprouts per tuber but fewer in the longer length categories above 10 mm. (Table 64). The effect of period of storage at high temperature was similar to that of the effect without T.C.N.B. with more sprouts above 30 mm. produced at the earlier desprouting date (4th January). In the case of low temperature storage with or without T.C.N.B. slightly more sprouts above 10 mm. were produced after the earlier date of desprouting (Table 64).

4. Total Number of Sprouts per Tuber (1 mm. and above)

The number of sprouts per tuber developed at the time of planting for the samples desprouted after varying storage treatments and sprouted in light are given in Appendix 45.

The number of sprouts formed per tuber at the time of planting is related to variety, seed size and condition of storage before sprouting in light.

(i) Size of Seed Tuber and Variety

Large seed tended to produce more sprouts than small seed from comparable samples. Thus, in Arran Pilot tubers desprouted on 4th January (d_1) the average numbers of sprouts developed per tuber at the end of the sprouting period (11th April) in large and small seed were 11.8 and 10.2 respectively, and in tubers desprouted on 20th February (d_2) the corresponding figures were 14.4 and 10.9. In Majestic large seed gave 6.8 and 8.4 sprouts per tuber for the two successive desprouting dates while small seed gave 5.8 and 7.2 (Table 65).

It may also be noted from the results (Table 65) that the two varieties differed in the average number of sprouts produced, the number being greater in Arran Pilot (with an average of 11.8 sprouts per tuber) than in Majestic (which averaged 7.0 sprouts per tuber).

(ii) Time of Desprouting

Tubers stored over the longer period before

TABLE 65

Effect of seed size and variety on the number of sprouts per tuber at the end of the sprouting period in light

Variety	No. of sprouts per tuber at the end of the sprouting period in light						Mean
	d_1			d_2			
	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	
Arran Pilot	11.8	10.2	11.0	14.4	10.9	12.6	11.8
Majestic	6.8	5.8	6.3	8.4	7.2	7.8	7.0
Mean	9.3	8.0	8.6	11.4	9.0	10.2	

N.B. d_1 = desprouted on 4.1.61; d_2 = desprouted on 20.2.61

desprouting (d_2) tended to produce more sprouts per tuber than those allowed to sprout earlier after desprouting (Table 65) but it may be seen in Table 66 that exceptions occurred where tubers had been previously stored for long periods (d_2) with T.C.N.B. at high temperature in the case of Arran Pilot or at medium temperature in the case of both varieties, indicating a possible adverse effect of these treatments on bud activity.

(iii) Effect of Temperature of Storage before Sprouting in Light on Subsequent Sprout Numbers Per Tuber

The number of sprouts per tuber at the end of the

TABLE 66

Effect of previous storage treatment on the number of sprouts per tuber at the end of the sprouting period in light

Storage Temperature	Arran Pilot						Majestic					
	Without T.C.N.B.			With T.C.N.B.			Without T.C.N.B.			With T.C.N.B.		
	d_1	d_2	Mean	d_1	d_2	Mean	d_1	d_2	Mean	d_1	d_2	Mean
High (65°-80°F)	10.2	13.9	12.0	11.2	9.6	10.4	5.5	6.2	5.8	7.7	8.9	8.3
Medium (50°-60°F)	9.7	13.6	11.6	11.7	9.0	10.3	5.3	6.3	5.8	1.9	1.0	1.4
Low (40°F)	10.7	12.7	11.7	12.6	17.1	14.8	9.1	12.9	11.0	8.3	11.4	9.8
Mean	10.2	13.4	11.8	11.8	11.9	11.8	6.6	8.5	7.5	6.0	7.0	6.5

N.B. d_1 = desprouted on 4.1.61; d_2 = desprouted on 20.[illegible].61

sprouting period in light (11th April) was also determined by the storage temperature before sprouting in light. Thus in both varieties and for both times of desprouting (d_1 and d_2) tubers stored at low temperature before sprouting in light showed a greater number of sprouts at the end of the sprouting period than those stored at high

TABLE 67

Effect of storage temperature on number of sprouts at the end of the sprouting period in light

Storage Temperature Before Sprouting in Light	Arran Pilot			Majestic		
	d_1	d_2	Mean	d_1	d_2	Mean
65°-80°F (High)	10.7	11.7	11.2	6.6	7.5	7.0
50°-60°F (Medium)	10.7	11.7	11.0	3.6	3.6	3.6
40°F (Low	11.6	14.9	13.2	8.7	12.1	10.4

d_1 = Desprouted on 4.1.61

d_2 = Desprouted on 20.2.61

or medium temperature (Table 67). In Arran Pilot the difference in the number of sprouts following medium and high temperature storage was negligible. However, in Majestic tubers storage at medium temperature resulted in a smaller number of sprouts than storage at high temperature, but this may be due to the adverse effect of T.C.N.B. at 50^{o}-60^{o}F where many tubers had failed to produce sprouts at the time of planting, although the tubers were apparently healthy and sound (Table 66).

(iv) Effect of a Sprout Inhibiting Chemical on the Number of Sprouts Per Tuber at the Time of Planting

The effect of T.C.N.B. on sprout numbers varied with variety, storage temperature, and period of storage with the chemical (Table 66). In Arran Pilot there was a slight tendency for more sprouts to develop in tubers previously treated with T.C.N.B. than in untreated tubers for the first desprouting treatment (Table 66) but with tubers stored for a longer period (d_2) at high or medium temperature T.C.N.B. treatment tended to reduce the number of sprouts produced. However, with T.C.N.B. at low temperature storage, the number produced was the highest of all treatments (Table 66).

In Majestic, T.C.N.B. treatment at high temperature showed a slight tendency to give increased sprout numbers in comparison with untreated, whereas there was little or a slightly reversed effect with low temperature storage.

Treatment with T.C.N.B. at medium temperature, however, had a very marked effect in reducing the number of sprouts produced (Table 66).

In considering the total number of sprouts per tuber, account has been taken of the number of sprouted eyes and the number of eyes with more than one sprout characteristic of tubers from the various samples, and data for these assessments are given in Appendices 46 and 47 respectively.

5. Sprouted Eyes Per Tuber

The numbers of sprouted eyes per tuber for each treatment are given in Table 69.

In Arran Pilot large size tubers tended to form more sprouted eyes per tuber than small tubers although the increase was slight, while in Majestic the differences between large and small seed were not consistent. Irrespective of seed size, however, Arran Pilot showed more sprouted eyes per tuber than Majestic (Table 68).

TABLE 68

Effect of seed size and variety on the number of sprouted eyes per tuber at the end of the sprouting period in light

Variety	No. of sprouted eyes per tuber at the end of the sprouting period in light						Mean
	d_1			d_2			
	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	
Arran Pilot	8.0	7.1	7.5	8.5	7.6	8.0	7.7
Majestic	5.1	4.7	4.9	5.3	5.1	5.2	5.0
Mean	6.5	5.9	6.2	6.9	6.3	6.6	

N.B. d_1 = desprouted on 4.1.61

d_2 = desprouted on 20.2.61

TABLE 69

Effect of previous storage treatment on the number of sprouted eyes per tuber at the end of the sprouting period in light, desprouted at different dates

Storage Temperature	Arran Pilot						Majestic					
	Without T.C.N.B.			With T.C.N.B.			Without T.C.N.B.			With T.C.N.B.		
	d_1	d_2	Mean	d_1	d_2	Mean	d_1	d_2	Mean	d_1	d_2	Mean
High (65°-80°F)	7.9	9.1	8.5	6.8	6.2	6.5	4.8	5.2	5.0	5.5	5.0	5.2
Medium (50°-60°F)	7.4	8.5	7.9	6.9	5.5	6.2	4.4	4.5	4.4	1.3	0.5	0.9
Low (40°F)	8.1	8.9	8.5	8.1	9.9	9.0	6.5	8.2	7.3	6.8	7.8	7.3
Mean	7.8	8.8	8.3	7.3	7.2	7.2	5.2	6.0	5.6	4.5	4.4	4.4

N.B. d_1 = desprouted on 4.1.61

d_2 = desprouted on 20.2.61

(i) Effect of Time of Desprouting on the Number of Sprouted Eyes per Tuber

Prolonged period of storage (d_2) following storage without T.C.N.B. tended to give a slightly greater number of sprouted eyes per tuber (Table 69). This effect was only seen with low temperature storage where tubers had been treated with T.C.N.B. while at medium and high temperatures longer periods of storage (d_2) with T.C.N.B. caused a reduction in the number of eyes which sprouted (Table 69). This behaviour, associated with period of storage under different storage conditions, was found to a greater or lesser extent in both varieties (Table 69).

(ii) Effect of Previous Temperature of Storage and Treatment with T.C.N.B. on the Number of Sprouted Eyes per Tuber at Planting Time

Tubers at low temperature, irrespective of variety,

TABLE 70

Effect of storage temperature before sprouting in light on the number of sprouted eyes per tuber at the end of the sprouting period in light

Storage Temperature	Arran Pilot			Majestic		
	d_1	d_2	Mean	d_1	d_2	Mean
High (65°-80°F)	7.3	7.6	7.4	5.1	5.1	5.1
Medium (50°-60°F)	7.1	7.0	7.0	2.8	2.5	2.6
Low (40°F)	8.1	9.4	8.7	6.6	8.0	7.3

d_1 = Desprouted on 4.1.61 d_2= Desprouted on 20.2.61

produced more sprouted eyes per tuber than those stored at higher temperatures (Table 70) although it may be seen from Table 69 that Arran Pilot stored without T.C.N.B. showed little response to temperature treatment. In Arran Pilot tubers stored at medium or high temperature with or without T.C.N.B. (average of date of desprouting) formed more or less the same number of sprouted eyes at the end of the sprouting period (Table 69 and 70). On the other hand, in Majestic the two temperature treatments gave similar results where tubers were stored without T.C.N.B. but when T.C.N.B. had been applied the number of sprouted eyes was less from medium temperature storage (Table 69).

In comparing T.C.N.B. and no T.C.N.B. treatments, where tubers were stored at low temperature in both varieties treatment with T.C.N.B. exerted no obvious effect on the number of sprouted eyes subsequently formed (Table 69). With higher temperatures of storage, however, T.C.N.B. reduced the number of sprouted eyes per tuber in Arran Pilot. In Majestic the reduction was very marked in the case of medium temperature storage, but at high temperature storage the numbers of sprouted eyes in T.C.N.B. treated and untreated tubers were more or less the same (Table 69).

TABLE 71

Effect of seed size and variety on the number of eyes having one or more sprouts at the end of the sprouting period in light

Variety	Number of eyes per tuber having one or more sprouts																			
	d_1										d_2									
	Large Seed					Small Seed					Large Seed					Small Seed				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Arran Pilot	5.60	1.36	0.85	0.21	0.01	4.96	1.15	0.83	0.10	-	4.60	2.20	1.35	0.30	-	5.21	1.61	0.56	0.18	-
Majestic	3.91	0.83	0.35	0.05	-	3.85	0.65	0.15	0.05	-	3.38	0.95	0.68	0.20	0.01	3.66	0.90	0.45	0.06	0.03
Mean	4.75	1.09	0.60	0.13	0.005	4.40	0.90	0.49	0.07	-	3.99	1.57	1.01	0.25	0.005	4.43	1.25	0.50	0.12	0.01

d_1 = Desprouted on 4.1.61

d_2 = Desprouted on 20.2.61

6. Number of Sprouts per Eye

In considering the number of sprouts developed per eye, it may be seen from Appendix 47 that the greater proportion of eyes on tubers from most treatments developed only one sprout. The number of eyes per tuber having more than one sprout at the end of the sprouting period may be related to seed size, variety and storage condition before sprouting in light.

(i) Seed Size and Variety

Large seed, averaged for storage treatments and varieties, tended to give a greater number of eyes having more than one sprout than small seed (Table 71). Similarly Arran Pilot, averaged for storage treatments, had more eyes which produced more than one sprout than Majestic (Table 71).

(ii) Time of Desprouting

In comparing time of desprouting or periods of storage before sprouting in light, it was noted that both large and small tubers stored over the longer periods before desprouting (d_2) tended to produce more eyes having over one sprout than those allowed to sprout earlier after desprouting (d_1) [Table 71]. It may, however, be seen in Table 72 and 73 respectively that exceptions occurred where tubers had been previously stored for longer periods (d_2) with T.C.N.B. at high temperature in the case of Arran Pilot or at medium temperature in Majestic,

TABLE 72

Effect of previous storage treatment on the number of eyes having one or more sprouts in Arran Pilot at the time of planting, sprouted in light after varying periods of storage

Storage Temperature before Sprouting in Light	Number of eyes per tuber having one or more sprouts																			
	d_1										d_2									
	Without T.C.N.B.					With T.C.N.B.					Without T.C.N.B.					With T.C.N.B.				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
High (65°-80°F)	6.3	1.10	0.50	0.05	-	3.90	1.80	0.95	0.15	0.05	5.60	2.35	1.00	0.15	-	3.90	1.40	0.65	0.25	-
Medium (50°-60°F)	5.7	1.15	0.50	0.05	-	3.95	1.45	1.15	0.35	-	5.00	2.25	1.10	0.20	-	3.35	1.50	0.30	0.40	-
Low (40°F)	6.55	0.80	0.60	0.20	-	5.30	1.25	1.35	0.20	-	6.15	1.85	0.90	0.05	-	5.45	2.10	1.80	0.50	-

d_1 = Desprouted on 4.1.61

d_2 = Desprouted on 20.2.61

indicating a possible adverse effect of these treatments on bud activity.

(iii) Effect of Previous Storage Treatment

In the case of Arran Pilot tubers stored without T.C.N.B. and desprouted on 4th January (d_1) the previous storage temperature appeared to have no marked effect on the number of sprouts produced per eye at the end of the sprouting period in light (11th April) [Table 72]. With the longer periods of storage (d_2) without T.C.N.B., however, at high and medium temperature a greater number of eyes developed more than one sprout compared with previous storage at low temperature, although the increases were slight (Table 72). With regard to T.C.N.B. treatment, high temperature treatment tended to give a smaller number of eyes with more than one sprout than low and medium temperature in the case of short periods of storage (d_1). When the period of exposure was prolonged until 20th February (d_2) low temperature treatment gave more eyes having over one sprout than that of high and medium temperature (Table 72). In comparing T.C.N.B. and no T.C.N.B. treatments there was a slight tendency for more sprouts to develop per eye in tubers treated with T.C.N.B., irrespective of previous temperature of storage, than in untreated tubers for the first desprouting treatments (d_1) but in tubers stored for longer periods (d_2) at high or medium temperature, T.C.N.B. treatment

TABLE 73

Effect of previous storage treatment on the number of eyes having one or more sprouts in Majestic at the time of planting, sprouted in light after varying periods of storage

Storage Temperature before Sprouting in Light	Number of eyes per tuber having one or more sprouts																			
	d_1										d_2									
	Without T.C.N.B.					With T.C.N.B.					Without T.C.N.B.					With T.C.N.B.				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
High (65°-80°F)	4.25	0.45	0.05	0.05	-	4.00	1.00	0.50	0.05	-	4.45	0.50	0.20	0.05	-	2.50	1.45	0.70	0.30	0.05
Medium (50°-60°F)	3.65	0.70	0.10	-	-	0.80	0.50	0.05	-	-	3.10	0.95	0.45	-	-	0.35	-	0.05	-	0.10
Low (40°F)	4.80	1.15	0.40	0.20	-	5.80	0.65	0.35	-	-	5.25	1.50	1.10	0.35	-	5.50	1.15	0.90	0.25	-

d_1 = Desprouted on 4.1.61

d_2 = Desprouted on 20.2.61

tended to reduce the number of eyes having more than one sprout. However, T.C.N.B. at low temperature gave a greater number of eyes with more than one sprout than comparable tubers stored without T.C.N.B. (Table 72).

In Majestic without T.C.N.B. increase in previous temperature of storage, irrespective of periods of exposure, tended to reduce the number of eyes having more than one sprout. In the case of T.C.N.B. treatment high temperature tended to produce more eyes having over one sprout than low temperature (irrespective of periods of exposure) and both of these temperature treatments gave a large number of eyes having more than one sprout compared with medium temperature (Table 73). In comparing T.C.N.B. and no T.C.N.B. treatment, treatment with T.C.N.B. at high temperature showed a slight tendency to give more eyes having over one sprout in comparison with untreated, whereas there was little or a slightly reversed effect with low temperature. Treatment with T.C.N.B. at medium temperature, however, had a very marked effect in reducing the number of eyes having one or more than one sprout (Table 73).

C. Studies on Plant Growth and Development

1. The Rate of Plant Emergence

To study the effect of different storage treatments on the rate of plant emergence (after planting on 28th April) counts of plants were made regularly twice a week from 10th May to 6th June. The final plant stand, recorded on 17th June, expressed as a percentage of the number of tubers initially planted is given in Table 74.

The data relating to the effect of different treatments on rate of plant emergence was subjected to statistical analysis and for this purpose a "Germination Rate Index" (Bartlett 1937) was calculated for each plot. The analysis of variance for the main effects of variety, seed size, date of desprouting and storage treatment and the interaction between these factors are shown in Appendix 50.

(i) Variety. It may be seen from Table 75 that plants of Arran Pilot emerged on average earlier than those of Majestic. There was, however, a significant interaction between variety, treatment and date of desprouting. Thus earlier emergence from Arran Pilot was evident when comparing the two varieties desprouted on 4th January (d_1) and on 20th February (d_2) before sprouting in light, but there was no significant difference between the two varieties averaged for the various storage treatments when the tubers were desprouted immediately before planting

(Table 75). It is also noted that tubers of Majestic stored at medium temperature without T.C.N.B. until near planting time showed earlier emergence than that of Arran Pilot stored over the same periods. This might be related to the retarding effect of low temperature on subsequent growth or the greater losses in tuber weight following higher temperature storage in the latter variety.

(ii) Seed Size. Large seed emerged earlier than small seed (Appendix 51), but the difference for different times of desprouting was only significant at the early desprouting date (Appendix 52) averaged for all storage treatments and there was a significant interaction between treatment, variety and seed size. In Majestic large seed stored at medium temperature with T.C.N.B. (averaged for three dates of desprouting) emerged significantly later than small seed stored at the same temperature (Appendix 53) which may result from the adverse effect of T.C.N.B. in combination with temperature on the vigour of sprout growth in the former case. In fact, in Majestic large seed stored at medium temperature with T.C.N.B. until January (d_1) or February (d_2) gave fewer sprouts and also shorter sprouts at the end of the sprouting period (11th April) than small seed (Appendix 44).

(iii) Date of Desprouting. Tubers desprouted immediately before planting (d_3) were significantly slower in emergence than those desprouted earlier and allowed to

TABLE 74

Effect of different storage treatments on final plant stand (as percentage of tubers initially planted) in Arran Pilot and Majestic

Storage Temperature	Arran Pilot						Majestic					
	Without T.C.N.B.			With T.C.N.B.			Without T.C.N.B.			With T.C.N.B.		
	d_1	d_2	d_3	d_1	d_2	d_3	d_1	d_2	d_3	d_1	d_2	d_3
High (65°-80°F)	100.0	87.5	56.25	100.0	96.25	6.25	100.0	76.25	42.5	97.5	67.5	26.25
Medium (50°-60°F)	100.0	100.0	47.50	100.0	93.75	32.50	100.0	100.0	88.75	36.25	12.50	13.75
Low (40°F)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

d_1 = Desprouted on 4.1.61

d_2 = Desprouted on 20.2.61

d_3 = Desprouted at the time of planting.

sprout in light (Appendix 52). Moreover, the earlier desprouting (d_1) treatment gave on average earlier emergence than late desprouting (d_2) (Appendix 52). However, the interaction between time of desprouting, treatment and variety was significant, and the effect of time of desprouting and storage treatment on rate of plant emergence are discussed separately for the two varieties.

Arran Pilot. With tubers sprouted on 4th January (d_1) neither temperature nor T.C.N.B. had any significant effect on the rate of plant emergence (Table 75 and Table 76) and all treatments gave complete plant stands. However, when the period of storage was extended until 20th February an unfavourable effect of previous storage at high temperature was evident. Thus with high temperature storage 96.25% of plants emerged where T.C.N.B. had been applied and only 87.5% where no T.C.N.B. had been applied; while medium temperature storage with T.C.N.B. also gave an incomplete plant stand with 93.75% final emergence (Table 74). Moreover, in plants that did emerge the rate of emergence was slower following high temperature storage in comparison with medium and low temperature storage. This effect was significant in tubers treated with T.C.N.B. comparing high with medium temperature in favour of medium temperature and in tubers stored without T.C.N.B. between high and low temperature in favour of low temperature for early plant emergence

(Table 75). Slow rate of emergence following prolonged periods of storage (until 20th February) at high temperature can also be illustrated in Table 76 which shows that in the case of T.C.N.B. treated tubers desprouted on 20th February (d_2) the percentage of plant emergence at high, medium and low temperature, 21 days after planting, was respectively 40%, 61% and 57.7% and without T.C.N.B. treatment the corresponding figures were 35%, 55% and 52.5% respectively.

With the exception of high temperature storage where a shorter storage period (until 4th January) before sprouting showed better emergence, there was no significant difference in the rate of plant emergence following medium and low temperature storage, irrespective of treatment with T.C.N.B., between tubers desprouted on 4th January (d_1) and those desprouted on 20th February (d_2) (Table 75).

Thus in Arran Pilot there was no advantage in early sprouting (4th January, i.e. d_1) with regard to early plant emergence except in the case of storage at 65^{o}-80^{o}F where excessive weight loss (24 to 25% total loss in tuber weight desprouted on 20th February) resulted from longer periods of storage and delayed subsequent plant emergence compared with tubers stored for shorter period at 65^{o}-80^{o}F (8.6 to 8.7% total loss in tuber weight desprouted on 4th January). In the case of medium and low temperature treatment, tubers stored for a short period (4th January) before sprouting in light, having large numbers of sprouts

TABLE 75

Germination Rate Index: Treatment x Variety x Date of Desprouting

Storage Treatment	Arran Pilot				Majestic				Mean
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean	
1. Stored at 65°-80°F without T.C.N.B.	0.723	0.564	0.176	0.488	0.662	0.525	0.212	0.466	0.477
2. Stored at 50°-60°F without T.C.N.B.	0.685	0.630	0.253	0.523	0.617	0.598	0.351	0.522	0.522
3. Stored at 40°F without T.C.N.B.	0.687	0.640	0.239	0.522	0.601	0.514	0.185	0.433	0.478
4. Stored at 65°-80°F with T.C.N.B.	0.705	0.581	0.125	0.470	0.651	0.461	0.125	0.412	0.441
5. Stored at 50°-60°F with T.C.N.B.	0.701	0.659	0.220	0.527	0.612	0.203	0.090	0.302	0.414
6. Stored at 40°F with T.C.N.B.	0.693	0.651	0.250	0.531	0.626	0.560	0.175	0.453	0.492
Mean	0.699	0.621	0.211	0.510	0.628	0.477	0.189	0.431	

d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting

S.E. of Variety ± 0.017
S.E. of Variety x Date of Desprouting ± 0.015
S.E. of Treatment ± 0.011
S.E. of Treatment x Variety ± 0.015
S.E. of Treatment x Variety x Date of Desprouting ± 0.026

of higher length categories (over 61 mm.) at the time of planting, failed to show any significantly earlier emergence than those stored for a longer period (until 20th February). This result is identical with that of Headford (1960 and 1962) who showed that sprout length above 15 mm. does not significantly hasten plant emergence.

Tubers planted directly after desprouting showed a much slower emergence rate (Table 75 and Table 76) than tubers sprouted in light during January (d_1) and February (d_2) and in the case of medium and high temperature treatment a marked reduction in the final plant stand was noted (Table 74). With regard to T.C.N.B. treatment, the reduction in final plant number was most marked at high temperature where there was only 6.25% final emergence; at medium temperature 32.5% of the plants emerged. Without T.C.N.B. the corresponding figures were 56.25% and 47.5% respectively (Table 74). With plants that did emerge for both T.C.N.B. and no T.C.N.B. treatments, tubers stored at high temperature produced plants above ground much later than those stored at medium and low temperature. In the case of untreated tubers (no T.C.N.B.), the difference between medium and high temperature in favour of medium temperature for early plant emergence was significant, but the differences between low and high or low and medium temperatures were not significant (Table 75). With regard to T.C.N.B.

TABLE 76

Effect of different storage treatments on plant emergence in Arran Pilot and Majestic

Arran Pilot

Storage Treatment	d1: Percentage of emergence of plant at different days after planting									d2: Percentage of emergence of plant at different days after planting									d3: Percentage of emergence of plant at different days after planting								
	12	14	18	21	25	28	32	35	39	12	14	18	21	25	28	32	35	39	12	14	18	21	25	28	32	35	39
Stored at 65°-80°F Without T.C.N.B.	11.2	16.2	56.2	75.0	93.7	98.7	100			1.2	1.2	18.7	35.0	66.2	75.0	81.2	82.5	87.5	0	0	0	0	1.2	2.5	8.7	18.7	45.0
Stored at 50°-60°F Without T.C.N.B.	6.2	8.7	43.7	66.2	95.0	97.5	98.7	100		1.2	2.5	40.0	55.0	82.5	91.2	96.2	98.7	100	0	0	0	0	1.2	5.0	23.7	31.2	51.2
Stored at 40°F Without T.C.N.B.	12.5	12.5	47.5	60.0	88.7	97.5	100			2.5	3.7	25.0	52.5	93.7	100				0	0	0	0	0	8.7	31.0	75.0	100
Stored at 65°-80°F With T.C.N.B.	7.5	7.5	61.2	66.2	95.0	98.7	98.7	100		0	0	18.7	40.0	77.5	88.7	93.7	95.0	96.0	0	0	0	0	0	0	2.5	2.5	6.2
Stored at 50°-60°F With T.C.N.B.	3.5	10.0	60.0	73.7	90.0	95.0	98.7	100		0	2.5	37.5	61.0	86.2	91.2	92.5	93.7	93.7	0	0	0	0	0	1.2	12.5	18.7	30.0
Stored at 40°F with T.C.N.B.	2.5	8.7	48.7	68.7	95.0	100				2.5	5.0	28.7	53.7	96.2	100				0	0	0	0	6.2	8.7	38.7	77.5	100

Majestic

Storage Treatment	d1									d2									d3								
	12	14	18	21	25	28	32	35	39	12	14	18	21	25	28	32	35	39	12	14	18	21	25	28	32	35	39
Stored at 65°-80°F Without T.C.N.B.	2.5	5.0	46.2	58.7	85.0	96.2	100			0	0	10.0	31.2	51.2	57.5	65.0	66.2	70.0	0	0	0	0	0	0	7.5	21.2	32.5
Stored at 50°-60°F Without T.C.N.B.	1.2	1.2	35.0	50.0	75.0	92.5	100			0	0	40.0	50.0	68.7	87.5	95.0	97.5	100	0	0	0	1.2	15.0	35.0	65.0	71.0	86.2
Stored at 40°F Without T.C.N.B.	1.2	3.7	30.0	43.7	70.0	95.0	97.5	100		0	0	13.7	23.7	53.7	76.2	95.0	100		0	0	0	0	0	1.2	13.7	51.2	100
Stored at 65°-80°F With T.C.N.B.	2.5	3.7	46.2	60.0	81.2	91.2	93.7	97.5	97.5	0	0	2.5	11.2	33.7	41.2	50.0	58.7	65.0	0	0	0	0	0	0	1.2	3.7	12.5
Stored at 50°-60°F With T.C.N.B.	0	0	8.7	16.2	22.5	26.2	27.5	27.5	30.0	0	0	0	2.5	5.0	6.2	6.2	7.5	7.5	0	0	0	0	0	0	0	1.2	13.7
Stored at 40°F With T.C.N.B.	3.7	6.2	41.2	45.0	73.7	96.2	98.7	98.7	100	0	0	32.5	35.0	60.0	81.2	95.0	100		0	0	0	0	0	0	6.2	47.5	100

N.B. d_1 = Desprouted on 4.1.61

d_2 = Desprouted on 20.2.61

d_3 = Desprouted at the time of planting.

treatment, tubers stored at medium and low temperatures produced plants above ground significantly earlier than those stored at high temperature. In spite of the dormant condition of tubers due to storage at low temperature throughout, the plants emerged significantly earlier than from tubers stored at high temperature and as early as the medium temperature treatment: this result indicates that the germinating power of the tuber was affected adversely by storage at medium temperature (total loss in weight of tuber 33-47%) and high temperature (total loss in weight of tuber 50-51%) on account of excessive loss in weight of the tuber.

Majestic. In tubers stored until 4th January (d_1) before desprouting, the combined effect of T.C.N.B. with medium or high temperature storage had an adverse effect on final plant stand (Table 74). After medium temperature storage only 36.25% of the tubers produced plants, whereas after high temperature storage the effect was slight giving 97.5% final emergence. In all other cases complete plant stands were eventually produced. In plants that did emerge, however, neither temperature nor T.C.N.B. treatment had any significant effect on the rate of emergence (Table 75).

With the longer period of storage before desprouting (until 20th February) the adverse effect of T.C.N.B. on final plant emergence was aggravated, with only 12.5%

final emergence from medium temperature storage and 67.5% from high temperature storage (Table 74). High temperature without T.C.N.B. also gave an incomplete final plant stand of 76.25%. The rate of plant emergence also varied according to the previous storage temperature and T.C.N.B. treatment. Tubers stored without T.C.N.B. emerged significantly earlier when previously stored at medium temperature than where storage had been at high or low temperature. This may be attributed to the longer length of sprouts in medium temperature treatment which showed a larger number of longer sprouts (Table 64) at the end of the sprouting period than those stored at high and low temperature. There was no significant difference between the effect of high and low temperature treatments on the rate of plant emergence. Early plant emergence following storage at medium temperature until February (d_2) can also be illustrated in Table 76 which shows that tubers stored at medium, high and low temperature without T.C.N.B. until 20th February (d_2) had 50%, 31% and 23% plant emergence respectively after 21 days of planting. In the case of T.C.N.B. treatment, tubers stored at medium temperature showed a significantly delayed emergence in comparison with low and high temperature treatments, while high temperature storage with T.C.N.B. had a less marked but significant delaying effect in comparison with low temperature storage (Table 75). Earlier emergence following low temperature treatment can also be illustrated in Table 76: tubers stored at low, high and medium temperature with T.C.N.B. until 20th February (d_2) had respectively 35%, 11.2% and 2.5% plant emergence after 21 days of planting. In comparing T.C.N.B. and no T.C.N.B. treatment, tubers stored at medium temperature without T.C.N.B. until 20th February (d_2) emerged earlier than those stored with T.C.N.B. for the same period, but at high and low temperatures the differences between T.C.N.B. and no T.C.N.B. were not significant (Table 75).

With the exception of medium temperature storage without T.C.N.B., tubers desprouted on 4th January emerged significantly earlier than those desprouted on 20th February (Table 75). It seems that in Majestic there is an advantage in early sprouting for early plant emergence. Early plant emergence in tubers stored for a short period (until 4th January) before sprouting can be illustrated in Table 76 which shows that tubers desprouted on 4th January (d_1) achieved 50% plant emergence between 18 to 21 days after planting, whereas 21 to 25 days were required in the case of tubers desprouted on 20th February (d_2).

Tubers planted immediately after removal of sprouts (d_3) produced plants above ground significantly later than sprouted tubers (d_1 and d_2) [Table 75] and only after low temperature storage were full plant stnads obtained (Table 76). In tubers stored with T.C.N.B. high temperature storage gave only 26.25% final emergence, while medium temperature storage produced a still lower figure - 13.75%. In tubers stored without T.C.N.B. the corresponding figures were somewhat higher reaching 42.5% in the case of high temperature and 88.75% in the case of medium temperature (Table 74). The rate of emergence was significantly higher from medium temperature storage without T.C.N.B. than from all other treatments, whereas T.C.N.B. at medium temperature resulted in a significantly slower rate of plant emergence than that from all other storage treatments. In both T.C.N.B. and no T.C.N.B. treatments the difference in rate of plant emergence between low and high temperature treatment was not significant (Table 75).

2. Observations on Plant Growth in the Field

Observations on plant growth during the growing season were made from the periodic lifting of plants at three week intervals from 56 to 119 days after planting. Dry weights of foliage and tubers were recorded at the different dates of sampling for the various treatments of each variety and the results are given in Appendix 55 and Tables 77, 78, 79 and 80. The figures are based on the average of six plants, three from each seed size. It may be seen from Appendix 55 that large seed tended to produce greater amounts of foliage and tubers than small seed but the effect was not consistent for all treatments being absent or reversed where tubers had been stored at higher temperature over a prolonged period. As the two varieties showed different responses to storage conditions the effects of treatment are considered separately for each variety.

Arran Pilot

(i) Seed Tubers Stored until 4th January before Sprouting in Light

While the previous storage conditions of seed tubers sprouted in January (d_1) did not show any significant effect on the rate of plant emergence (Table 75 and 76), the subsequent growth of plants appeared to be considerably influenced by the storage temperature. Growth of foliage, irrespective of T.C.N.B. treatment, was notably restricted

TABLE 77

Effect of different storage treatments on the dry weight (gm.) of foliage per plant at different stages of plant growth in Arran Pilot (average of two seed sizes)

Storage Temperature	Without T.C.N.B.												With T.C.N.B.											
	d_1				d_2				d_3				d_1				d_2				d_3			
	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4
High (65^o-80^oF)	5.08	2.11	3.33	0	1.42	0	0	0	0.16	1.90	3.67	0.33	1.41	2.11	5.66	0	1.88	1.33	0.83	1.50	0.15	0	1.83	0
Medium (50^o-60^oF)	11.22	14.33	12.50	2.11	8.33	4.0	5.0	0	0.34	2.70	1.50	0	6.81	9.38	9.97	19.00	3.11	13.00	4.83	0.33	0.54	0.35	9.48	10.16
Low (40^oF)	19.20	36.66	30.67	9.0	23.50	29.33	43.33	12.00	12.33	33.50	54.38	29.66	18.00	35.50	24.50	9.11	23.83	23.50	17.17	7.50	19.41	25.50	43.00	27.83

d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting

l_1 = Lifted 56 days after planting
l_2 = Lifted 77 days after planting
l_3 = Lifted 98 days after planting
l_4 = Lifted 119 days after planting

TABLE 78

Effect of different storage treatments on the dry matter (gm) production of tubers per plant at different stages of plant growth in Arran Pilot (average of two seed sizes)

Storage Temperature	Without T.C.N.B.											
	d_1				d_2				d_3			
	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4
High (65^o–80^oF)	9.41	9.67	21.50	31.0	4.33	5.67	5.66	4.00	0.08	4.75	9.17	4.17
Medium (50^o–60^oF)	16.5	43.5	77.83	42.33	14.91	15.0	30.16	13.38	0.34	1.96	6.17	3.75
Low (40^oF)	29.83	74.33	174.83	142.5	10.66	76.50	149.16	150.50	2.23	57.00	163.83	189.83

Storage Temperature	With T.C.N.B.											
	d_1				d_2				d_3			
	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4
High (65^o–80^oF)	5.25	7.50	42.0	19.62	5.83	8.16	11.00	26.66	0.04	0	4.0	0
Medium (50^o–60^oF)	12.50	54.25	50.50	26.16	5.92	19.5	30.83	11.66	4.58	4.01	42.0	16.33
Low (40^oF)	13.41	73.50	126.16	131.83	10.92	66.66	85.33	115.50	4.0	40.92	114.16	172.33

d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting

l_1 = Lifted 56 days after planting
l_2 = Lifted 77 days after planting
l_3 = Lifted 98 days after planting
l_4 = Lifted 119 days after planting

in seed tubers previously stored at high temperature and was also reduced in seed tubers stored at medium temperature in comparison with those stored at low temperature (Table 77). In the case of both T.C.N.B. treated and untreated seed, the growth of tubers was also adversely affected from high and medium temperature treatment (Table 78). Maximum dry matter (gm.) of foliage and tubers per plant on any date of sampling was generally found in seed tubers stored at low temperature with lowest dry matter followed high temperature treatment irrespective of T.C.N.B. (Table 77 and 78). It was also observed that with high and medium temperature treatments the mother tuber sometimes formed many small tubers underground with practically no growth of foliage, i.e. a 'little potato' effect (Davidson 1958). Plate 4 A shows the restricted growth of foliage and tubers at first sampling date associated with higher temperature of storage before sprouting.

(ii) Seed Tubers Stored until 20th February before Sprouting in Light

The unfavourable effect of high and medium temperature treatments on subsequent plant development was more marked when the period of exposure was prolonged until February (d_2) and the incidence of 'little potato' also increased (Plate 4 B taken at first sampling date). In February sprouted seeds, irrespective of T.C.N.B. treatment,

PLATE 4

EXPERIMENT 4 (1960-61)

SHOWING GROWTH OF FOLIAGE AND TUBER YIELD AT FIRST LIFTING DATE (56 DAYS AFTER PLANTING, I.E. 29th JUNE) IN ARRAN PILOT AS INFLUENCED BY DIFFERENT STORAGE TREATMENTS BEFORE SPROUTING OR PLANTING

A. STORED UNTIL 4th JANUARY (d_1)

B. STORED UNTIL 20th FEBRUARY (d_2)

C. STORED UNTIL PLANTING TIME (d_3)

I.	STORED AT	65°-80°F	WITHOUT	T.C.N.B.
II.	" "	50°-60°F	"	"
III.	" "	40°F	"	"
IV.	STORED AT	65°-80°F	WITH	T.C.N.B.
V.	" "	50°-60°F	"	"
VI.	" "	40°F	"	"

maximum dry weight of foliage and tubers was again found at low temperature, intermediate at medium and lowest at high temperature at comparable sampling dates (Table 77 and 78).

(iii) Seed Tubers Planted Directly from Storage

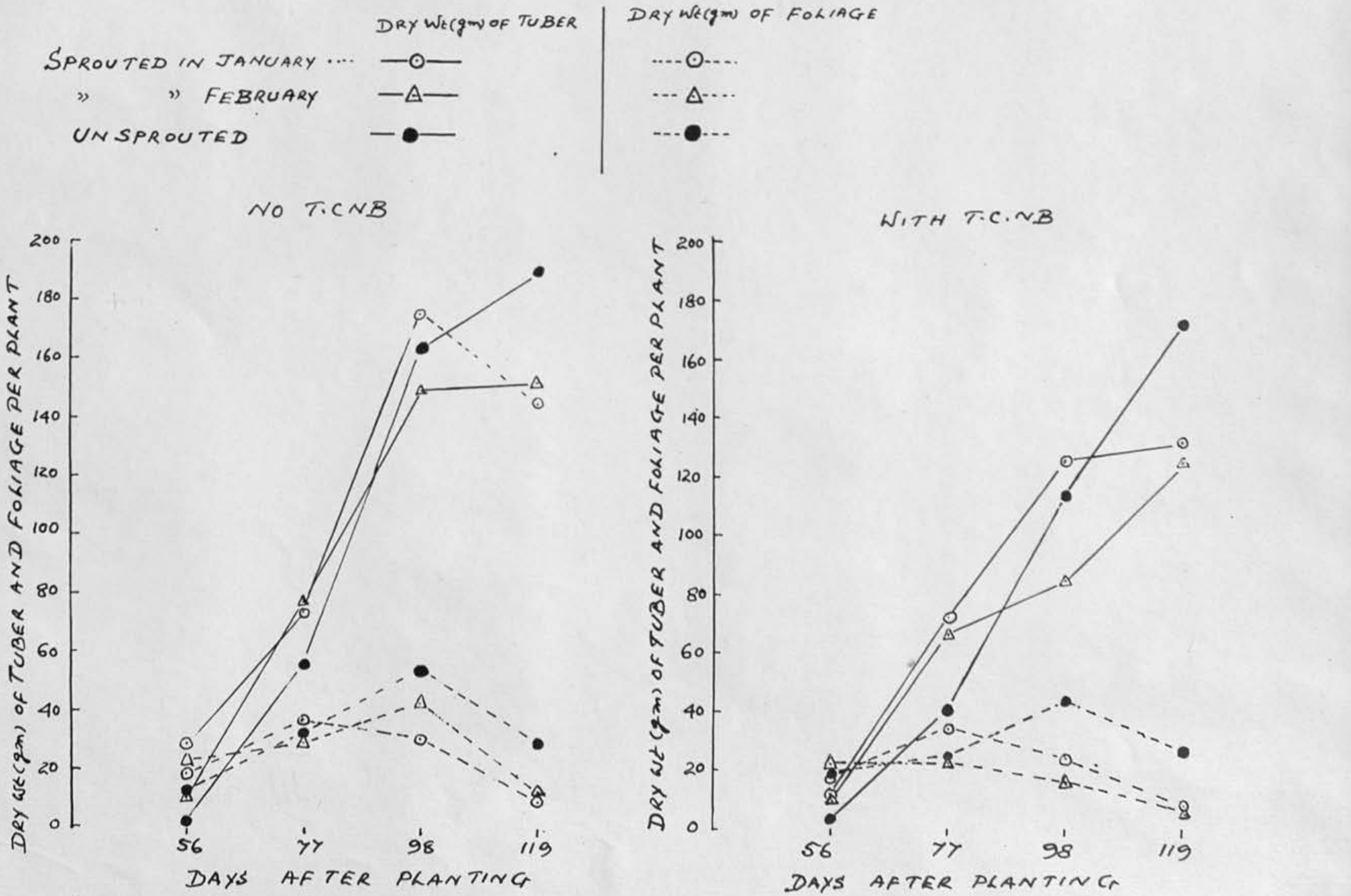
With seed tubers planted directly from storage after desprouting the unfavourable effect of medium and high temperature on subsequent plant development was again evident (Plate 4 C taken at first sampling date) giving rise in most cases to a 'little potato' type of tuber formation (Table 77 and 78).

Seed tubers planted directly from storage emerged significantly later than sprouted seeds irrespective of storage treatment (Table 75 and 76), but it is interesting to note that while unsprouted seeds at low temperature (d_3), regardless of T.C.N.B. treatment, formed a smaller amount of dry weight of tubers than those sprouted during January (d_1) and February (d_2) after medium and high temperature storage during the first sampling (56 days after planting), at all later dates they produced a greater amount of dry weight of foliage and tubers (Table 77 and 78).

(iv) Seed Tubers Stored at Low Temperature (40°F) before Sprouting or Planting

In considering the effects of sprouting on seed tubers stored at low temperature in comparison with unsprouted

Fig.13 EFFECT OF VARYING PERIODS OF LOW TEMPERATURE(40°F) STORAGE AND OF T.C.N.B. TREATMENT ON THE DRY MATTER PRODUCTION OF TUBERS AND FOLIAGE PER PLANT AT DIFFERENT STAGES OF PLANT DEVELOPMENT IN ARRAN PILOT.



seeds (d_3), while sprouted seeds (January and February, i.e. d_1 and d_2) gave earlier emergence and some advantage in early growth, the foliage showed earlier senescence and at the final two liftings (98 and 119 days after planting), tuber yields from sprouted (d_1 and d_2) and unsprouted seeds (d_3) were more or less similar, but with a tendency for yields to be higher from unsprouted seeds (d_3) [Fig. 13]. It seems that irrespective of T.C.N.B. treatment, growth and senescence of leaves varies according to the time of sprouting. Earlier growth of foliage in sprouted seeds may give more rapid tuber production in the early growth stage, but early senescence of leaves may restrict the further growth of tubers in comparison with unsprouted seed (d_3). It may also be seen from Fig. 13 that untreated (no T.C.N.B.) seeds tended to produce greater dry weights of tuber and foliage than T.C.N.B. treated seeds on any date of sampling.

Majestic

(i) Seed Tubers Stored until 4th January before Sprouting in Light

In seed tubers sprouted during January (d_1) the effect of previous storage temperature on plant growth and development varied according to whether or not seed tubers had been treated with T.C.N.B. (Table 79 and 80). Storage at high or at medium temperature without T.C.N.B. until January (d_1) tended to give earlier plant emergence

TABLE 79

Effect of different storage treatments on the dry weight (gm.) of foliage per plant at different stages of plant growth in Majestic (average of two seed sizes)

Without T.C.N.B.

Storage Temperature	d_1				d_2				d_3			
	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4
High (65°-$80^\circ F$)	27.92	34.33	53.00	30.83	5.11	9.83	11.50	2.50	1.13	4.83	1.91	2.00
Medium (50°-$60^\circ F$)	32.41	37.14	58.67	40.17	19.66	35.00	23.17	17.50	0.75	9.83	4.11	0.83
Low ($40^\circ F$)	30.75	51.66	53.67	43.33	34.91	51.66	92.83	53.50	16.41	56.17	90.66	61.66

With T.C.N.B.

Storage Temperature	d_1				d_2				d_3			
	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4
High (65°-$80^\circ F$)	24.50	22.33	38.33	19.67	7.20	6.66	0.16	0	0.09	0	4.83	5.00
Medium (50°-$60^\circ F$)	13.33	22.11	41.50	4.61	0	8.83	16.33	5.67	0	0	1.5	2.33
Low ($40^\circ F$)	27.41	40.83	64.50	50.00	32.66	44.83	62.50	52.67	19.50	44.67	59.17	57.50

d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting

l_1 = Lifted 56 days after planting
l_2 = Lifted 77 days after planting
l_3 = Lifted 98 days after planting
l_4 = Lifted 119 days after planting

TABLE 80

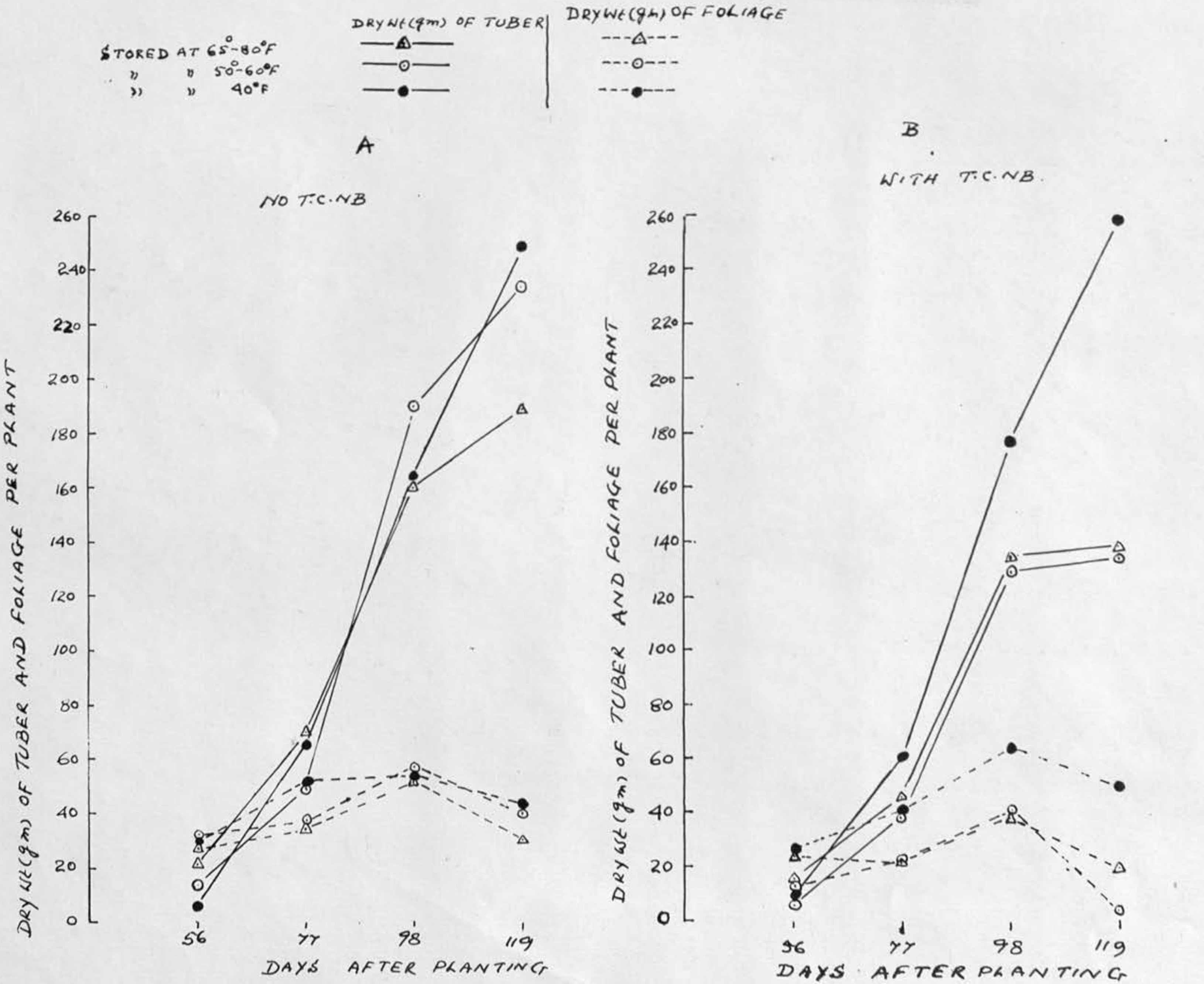
Effect of different storage treatments on the dry matter (gm.) production of tubers per plant at different stages of plant growth in Majestic (average of two seed sizes)

Storage Temperature	Without T.C.N.B.												With T.C.N.B.											
	d_1				d_2				d_3				d_1				d_2				d_3			
	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4
High (65^o-80^oF)	21.0	70.17	161.33	189.33	11.75	15.53	31.83	20.83	1.93	4.33	4.50	9.33	16.58	46.50	134.16	137.67	7.84	13.68	3.83	4.50	0.43	0.08	5.83	17.66
Medium (50^o-60^oF)	14.33	50.50	191.33	234.67	14.17	66.16	84.0	122.33	5.83	20.66	33.83	18.66	7.50	39.50	129.83	134.33	0	9.0	34.16	23.00	0	0	8.50	9.83
Low (40^oF)	7.75	67.50	165.16	249.33	15.91	84.0	221.17	266.33	0.44	53.00	172.00	226.00	9.75	60.00	177.16	258.67	15.33	64.00	153.67	243.16	3.54	40.0	133.66	238.33

d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting

l_1 = Lifted 56 days after planting
l_2 = Lifted 77 days after planting
l_3 = Lifted 98 days after planting
l_4 = Lifted 119 days after planting

Fig.14 EFFECT OF STORAGE AT DIFFERENT TEMPERATURES WITH OR WITHOUT T.C.N.B. UNTIL 4.1.61 BEFORE SPROUTING IN LIGHT ON THE DRY MATTER PRODUCTION OF TUBERS AND FOLIAGE PER PLANT AT DIFFERENT STAGES OF PLANT DEVELOPMENT IN MAJESTIC.



followed by higher tuber yields up to the third sampling date (98 days after planting) compared with storage at low temperature. On the fourth sampling date (119 days after planting), however, maximum dry weight of tubers was noted for low temperature, intermediate for medium and lowest for high temperature treatments (Fig. 14 A). Storage at medium and high temperature with T.C.N.B. gave lower yields of tubers and foliage than low temperature storage from the second sampling date (77 days after planting) onwards (Fig. 14 B). At low temperature there was no marked difference between T.C.N.B. treated and untreated seeds with regard to the growth of foliage and tuber production of plant, whereas at medium and high temperature treatment untreated (no T.C.N.B.) seeds gave a greater dry weight of tubers and foliage than those stored with T.C.N.B. irrespective of time of lifting (Fig. 14 A and B) [Plate 5 A taken at first sampling date].

(ii) Seed Tubers Stored until 20th February before Sprouting in Light

An unfavourable effect of medium and high temperature storage, irrespective of T.C.N.B. treatment, on subsequent growth of foliage and tuber production of plants with prolonged exposure was very evident in Majestic (Plate 5 B taken at first sampling date). Thus seed tubers stored at medium and high temperature, irrespective of T.C.N.B.

PLATE 5

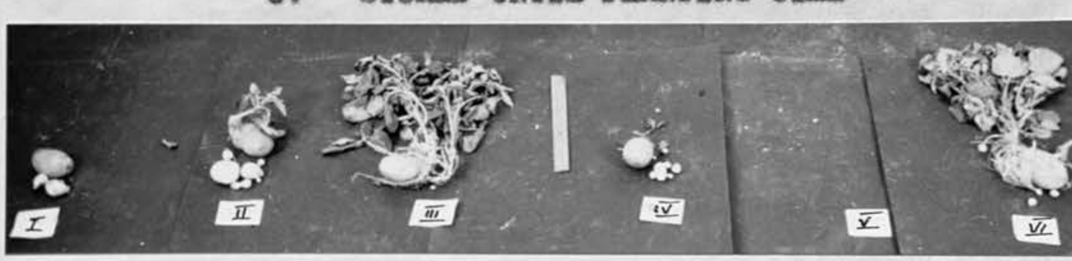
EXPERIMENT 4 (1960-61)

SHOWING GROWTH OF FOLIAGE AND TUBER YIELD AT FIRST LIFTING DATE (56 DAYS AFTER PLANTING, I.E. 29th JUNE) IN MAJESTIC AS INFLUENCED BY DIFFERENT STORAGE TREATMENTS BEFORE SPROUTING OR PLANTING

A. STORED UNTIL 4th JANUARY

B. STORED UNTIL 20th FEBRUARY

C. STORED UNTIL PLANTING TIME



I. STORED AT 65^{o}-80^{o}F WITHOUT T.C.N.B.

II. " " 50^{o}-60^{o}F " "

III. " " 40^{o}F " "

IV. STORED AT 65^{o}-80^{o}F WITH T.C.N.B.

V. " " 50^{o}-60^{o}F " "

VI. " " 40^{o}F " "

treatment, until 20th February (d_2) gave a smaller dry weight of foliage and tuber at any date of sampling than those stored at low temperature (Table 79 and 80). At high and medium temperature T.C.N.B. treated seeds showed smaller dry weight of tuber and foliage at different dates of sampling than comparable tubers stored without T.C.N.B. At low temperature there was no marked effect of T.C.N.B. on dry matter production of tubers and foliage (Table 79 and 80).

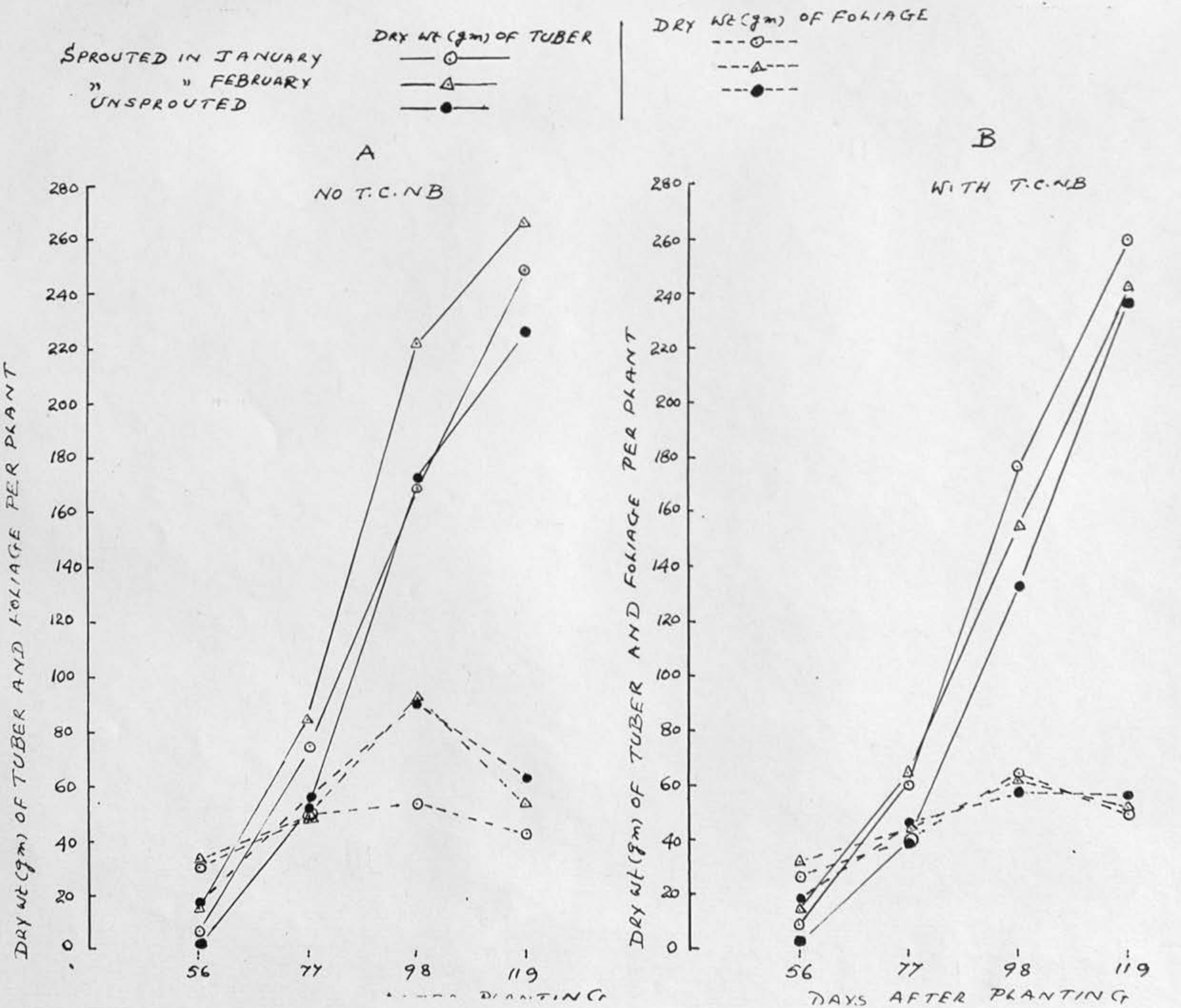
(iii) Seed Tubers Planted Directly from Storage

The depressing effect of high and medium temperature storage, irrespective of T.C.N.B. treatment, was also marked where storage was prolonged until planting time (d_3). In the case of seed tubers stored without T.C.N.B., the reduction in tuber yield was less at medium than at high temperature, whereas seed tubers previously treated with T.C.N.B. yielded eratically in all cases (Plate 5 C taken at first sampling date). Seed tubers stored at low temperature, irrespective of T.C.N.B. treatments, gave maximum dry weight of foliage and tubers at different dates of sampling (Table 79 and 80).

(iv) Seed Tubers Stored at Low Temperature before Sprouting or Planting

Seed tubers stored at low temperature and sprouted in light on 4th January (d_1) and 20th February (d_2), irrespective of T.C.N.B. treatment, produced greater dry

Fig.15 EFFECT OF VARYING PERIODS OF LOW TEMPERATURE(40°F) STORAGE AND OF T.C.N.B. TREATMENT ON THE DRY MATTER PRODUCTION OF TUBERS AND FOLIAGE PER PLANT AT DIFFERENT STAGES OF PLANT DEVELOPMENT IN MAJESTIC.



weights of tubers than those stored throughout (d_3) at any date of sampling (Table 80 and Fig. 15 A and B). It may be noted in Fig. 15 A and B respectively that seeds stored at low temperature without T.C.N.B. until 20th February (d_2) and in the case of T.C.N.B. treated seeds until 4th January (d_1) tended to show maximum tuber production.

TABLE 81

Average number of tuber bearing stems per plant in two seed sizes of two varieties

Variety	Large Seed			Small Seed			Mean		
	Main Stem	Underground branch with stolon	Total	Main Stem	Underground branch with stolon	Total	Main Stem	Underground branch with stolon	Total
Arran Pilot	2.27	2.85	5.12	1.80	2.01	3.81	2.03	2.43	4.46
Majestic	1.90	0.93	2.83	1.50	0.90	2.40	1.70	0.91	2.61
Mean	2.08	1.89	3.97	1.65	1.45	3.10			

TABLE 82

Effect of seed size and variety on number of aerial stems in 1000/acre

Variety	Seed Size		Mean
	Large	Small	
Arran Pilot	98.52	78.41	88.46
Majestic	40.14	34.08	37.11
Mean	69.33	56.24	

S.E. of Seed Size ±1.46   S.E. of V x S ±2.06

3. Numbers of Stems per Plant

The numbers of main stems from the seed tubers and underground branches from the main stem forming aerial stems and able to bear tubers were recorded during the first three sampling dates from the small scale experimental plot and the means of three dates of sampling for the various treatments have been presented in Appendix 56. In addition, counts of aerial stems in the yield trial were made on 17th June and the data subjected to statistical analysis (Appendix 57).

The number of main stems as well as underground branches giving rise to aerial stems varied with variety, Arran Pilot forming a greater number of stems per plant than Majestic averaged for all treatments and seed size (Table 81). This can be supported from the results of the yield trial experiment which indicated that Arran Pilot had a significantly greater number of aerial stems per acre than Majestic (Table 82). In both varieties large seed formed a greater number of stems than small seed (Table 81) and the difference in favour of large seed was significant (Table 82). However, the effect of seed size was not consistent for all treatments, being absent or reversed where tubers had been stored at higher temperature over a prolonged period (Appendix 56).

The effects of different storage treatments on the numbers of main stem and underground branches from the main stem per plant (averaged for the two seed sizes) may be conveniently considered separately for the two varieties.

Arran Pilot. Irrespective of T.C.N.B. treatment and time of desprouting, increase in temperature of storage before sprouting in light caused a decrease in the number of main stems as well as underground branches from the main stem (Table 83). Table 63 showed that seeds stored at high and medium temperature, irrespective of T.C.N.B. and time of desprouting, formed a larger number of sprouts between 31-60 and over 60 mm. at the end of the sprouting period (11th April) than those stored at low temperature. It seems that previous storage at medium and high temperature, however, had an adverse effect on subsequent terminal or axillary bud activity. This adverse effect of medium and high temperature was more marked when the period of exposure was prolonged (Table 83 and 85). The main effect of storage treatment (average of three dates of desprouting) indicated that the numbers of aerial stems (main + underground branches from the main stem) were maximum for low temperature, intermediate for medium and lowest for high temperature treatments, regardless of T.C.N.B. treatment (Table 85). The differences between low and medium in favour of low temperature and between medium and high in favour of medium temperature were significant (Table 85).

With respect to the effect of time of sprouting in

TABLE 83

Effect of different storage treatments on the number of tuber-producing stems per plant (average of two seed sizes and three dates of sampling) in Arran Pilot

Storage Temperature	Without T.C.N.B.									With T.C.N.B.								
	d_1			d_2			d_3			d_1			d_2			d_3		
	M.S.	U.B.	Total	M.S.	U.B.	Total	M.S.	U.B.	Total	M.S.	U.B.	Total	M.S.	U.B.	Total	M.S.	U.B.	Total
High (65^o-80^oF)	1.05	0.78	1.83	0.11	0.33	0.44	0.66	0.06	0.72	0.89	0.33	1.22	0.72	0.27	0.99	0.50	0	0.50
Medium (50^o-60^oF)	2.05	3.34	5.39	1.50	1.88	3.38	0.89	0.11	1.00	1.66	2.84	4.50	1.77	1.34	3.11	0.83	0.67	1.50
Low (40^oF)	2.44	6.28	8.72	3.66	7.50	11.16	6.72	1.78	8.50	2.44	7.00	9.44	2.94	6.39	9.33	5.77	2.92	8.69

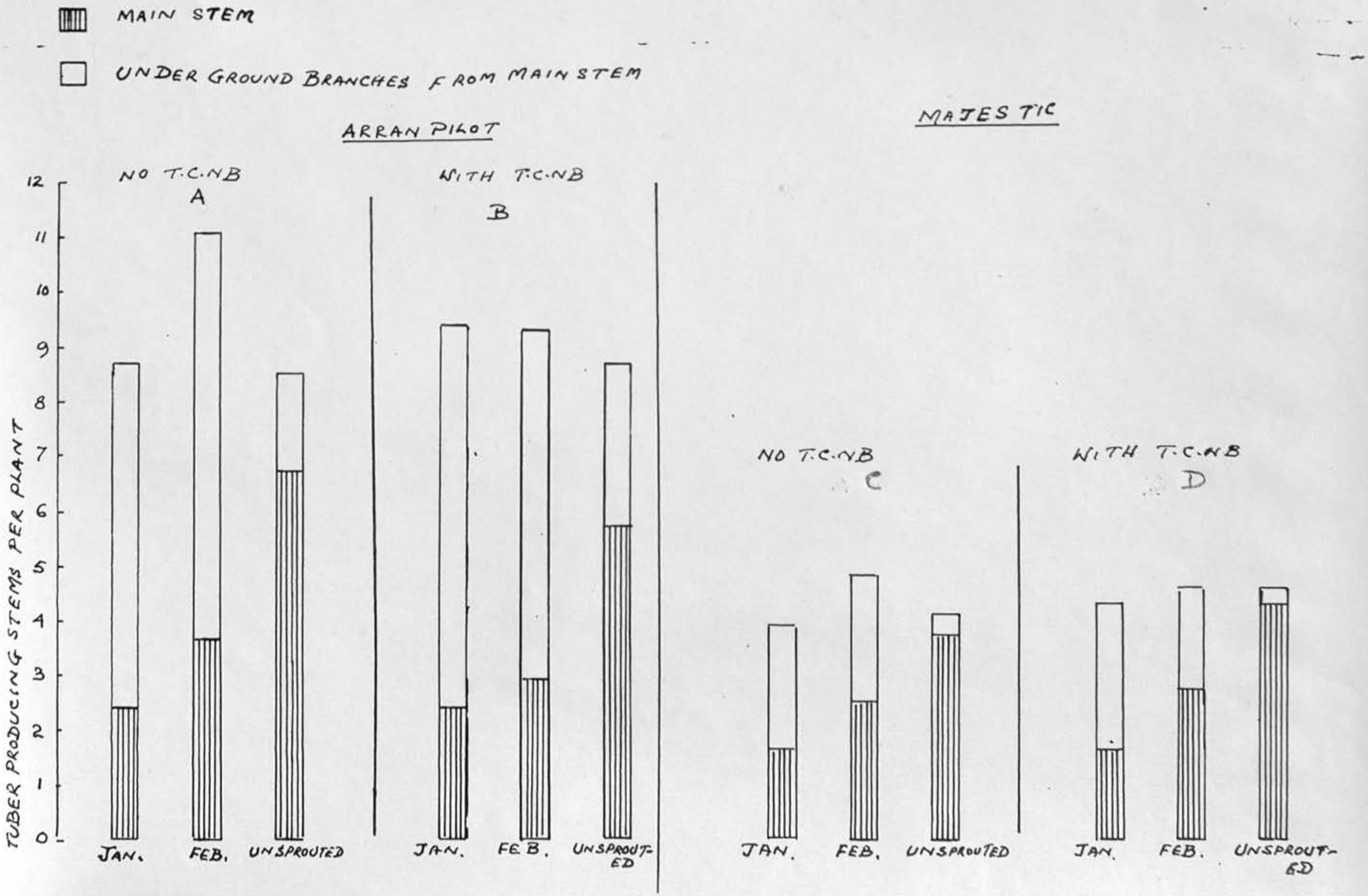
d_1 = Desprouted on 4.1.61
d_2 = " " 20.2.61
d_3 = " at the time of planting

M.S. = Main Stem

U.B. = Underground branches from main stem bearing tuber light on subsequent stem numbers per plant, seed tubers from low temperature treatment may be taken as an example as they did not suffer any excessive loss in weight for any of the three periods of storage. Irrespective of T.C.N.B. treatment, sprouted seeds (d_1 and d_2) formed a significantly greater number of aerial stems per acre than unsprouted seeds (Table 85). This increase in stem number (Table 85) from sprouted (d_1 and d_2) seed compared with unsprouted seed (d_3), however, appeared to be due to a greater numbers of underground branches from the main stem (Table 83) and the actual numbers of main stems may be less in sprouted seed. This is indicated in Fig. 16 A and B where longer periods of low temperature storage before sprouting or planting resulted in an increase in numbers of main stems but a decrease in underground branches. As a result of the greater numbers of underground branches, sprouted seeds showed significantly larger numbers of aerial stems per acre than unsprouted seeds (Table 85). It may also be noted that February (d_2) sprouted seeds which formed more sprouts than January (d_1) sprouted seeds (Table 63) gave rise to more main stems (Fig. 16 A and B).

With regard to main stem development in the case of low temperature treatment, this result agrees with that of Toosey (1960) who indicated that delay in sprouting from low temperature storage caused an increase in sprout numbers and subsequently increased the numbers of main

Fig.16 EFFECT OF VARYING PERIODS OF LOW TEMPERATURE(40°F) STORAGE AND OF T.C.N.B. TREATMENT ON THE NUMBER OF TUBER PRODUCING STEMS (MAIN STEMS + UNDER GROUND BRANCHES FROM MAIN STEMS) PER PLANT.



stems per plant. However, it seems from the above result that the number of underground branches able to form tubers cannot be entirely ignored in considering stem development and that the length of sprout growth and axillary bud activity are also factors to be taken into account with respect to the number of potential sites for tuber formation. The difference in aerial stem numbers (main stem + underground branches) between T.C.N.B. treated and untreated seeds at low temperature on any date of sprouting was not significant (Table 85).

Majestic. A decrease in stem numbers associated with previous storage at high and medium temperature was quite evident in Majestic. This effect of higher temperature on stem development was found to a greater or lesser extent in T.C.N.B. treated and untreated seed and was accentuated with longer period of storage (Table 84 and 85).

When the period of heat treatment was short, until January (d_1) (with the exception of T.C.N.B. at medium temperature), there was no significant difference in aerial stem number (main stem + underground branch) per acre between the different storage treatments (Table 85). Table 64 showed that seeds stored at high temperature (irrespective of T.C.N.B.) and at medium temperature (without T.C.N.B.) tended to give a larger number of sprouts between 31-60 mm. than those stored at low

TABLE 84

Effect of different storage treatments on the number of tuber-producing stems per plant (average of two seed sizes and three dates of sampling) in Majestic

Storage Temperature	Without T.C.N.B.									With T.C.N.B.								
	d_1			d_2			d_3			d_1			d_2			d_3		
	M.S.	U.B.	Total	M.S.	U.B.	Total	M.S.	U.B.	Total	M.S.	U.B.	Total	M.S.	U.B.	Total	M.S.	U.B.	Total
High (65°-80°F)	2.44	1.06	3.50	0.78	0.27	1.05	0.55	0.05	0.61	2.28	1.44	3.72	0.83	0.11	0.94	0.33	0.11	0.44
Medium (50°-60°F)	1.66	2.17	3.83	1.89	0.44	2.33	0.88	0.06	0.94	1.66	0.61	2.27	0.50	0	0.50	1.22	0.05	0.27
Low (40°F)	1.67	2.27	3.94	2.49	2.39	4.88	3.72	0.45	4.17	1.61	2.78	4.39	2.78	1.88	4.66	4.33	0.32	4.65

d_1 = Desprouted on 4.1.61
d_2 = " " 20.2.61
d_3 = " at the time of planting

M.S. = Main Stem
U.B. = Underground branches from main stem bearing tubers

TABLE 85

Effect of different storage treatments on the number (thousands) of aerial stems per acre in Arran Pilot and Majestic (average of two seed sizes)

Storage Treatment	Arran Pilot				Majestic				Mean
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean	
1. Stored at 65°-80°F without T.C.N.B.	88.41	50.66	17.26	52.11	51.79	22.10	13.71	29.20	40.65
2. Stored at 50°-60°F without T.C.N.B.	140.20	95.35	13.07	82.87	55.34	42.43	25.33	41.03	61.95
3. Stored at 40°F without T.C.N.B.	156.98	159.56	88.89	135.14	61.47	64.37	48.40	58.08	96.61
4. Stored at 65°-80°F with T.C.N.B.	103.74	67.27	1.13	57.38	53.24	25.97	6.94	28.72	43.05
5. Stored at 50°-60°F with T.C.N.B.	119.71	77.28	13.23	70.07	14.36	3.06	2.90	6.78	38.42
6. Stored at 40°F with T.C.N.B.	161.98	150.36	87.28	133.21	62.11	63.40	50.98	58.83	96.02
Mean	128.50	100.08	36.81	88.46	49.72	36.89	24.71	37.11	

d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting.

S.E. of Variety ±1.46
S.E. of Variety x Date of Desprouting ±2.53
S.E. of Treatment ±1.68
S.E. of Treatment x Variety ±2.36
S.E. of Treatment x Variety x Date of Desprouting ±4.10

temperature. It seems that previous storage at medium and high temperature, however, had an adverse effect on subsequent terminal or axillary bud activity and reduced the number of aerial stems per acre (Table 85).

The main effect of storage treatment (average of three dates of desprouting) indicated that untreated seeds (no T.C.N.B.) stored at low temperature gave a significantly greater number of aerial stems per acre than those stored at medium temperature and both of these temperature treatments produced a significantly greater number of stems than high temperature treatment. In the case of T.C.N.B. treatment maximum number of aerial stems were formed at low temperature, intermediate at high and lowest at medium temperature and the differences are significant (Table 85).

Summarising the effect of period of sprouting on subsequent development of stem number per plant after low temperature storage (irrespective of T.C.N.B. treatment), sprouted seeds (January and February sprouted) formed a significantly greater number of aerial stems per acre than unsprouted seeds (planted directly from cold storage) [Table 85]. This significant difference in stem number per acre may again be related to the greater number of underground branches produced from the main stem in the case of the sprouted seeds (Table 84 and Fig. 16 C and D).

Fig. 16 C and D indicate that the number of main stems formed per plant varies directly with delay in sprouting in light, whereas the number of underground branches from the main stem able to produce tubers is inversely proportional to the delay in sprouting and is presumably related to sprout length at planting time (Table 64). Irrespective of T.C.N.B. there was no significant difference in the number of aerial stems (main stem + underground branches) per acre between January (d_1) and February sprouted (d_2) seeds (Table 85). However, February sprouted seeds formed a greater number of main stems than January sprouted seeds (Table 84 and Fig. 16 C and D). Table 64 shows that tubers sprouted during February (d_2) from low temperature storage formed more sprouts per tuber than those sprouted during January (d_1) from the same temperature, indicating that the number of main stems varied directly with the number of sprouts per seed tuber.

TABLE 86

Number of tubers per plant in two seed sizes of two varieties at different stages of plant growth (average of treatment)

Variety	Number of tubers per plant on different days after planting											
	56			77			98			119		
	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean
Arran Pilot	11.05	8.92	9.98	10.94	8.41	9.67	10.89	7.98	9.43	9.02	7.00	8.01
Majestic	13.37	8.96	11.16	11.81	9.22	10.52	9.54	7.74	8.64	8.31	5.80	7.05

4. Number of Tubers per Plant at Different Stages of Plant Growth

The number of tubers per plant (average of three plants) recorded at the different dates of sampling for the various treatments has been presented in Appendix 58 and the tuber numbers (averaged for the two seed sizes) in different size categories according to diameter are given in Appendix 59.

(i) Seed Size. In both varieties the number of tubers formed per plant varied with the size of seed tuber (average for the various storage treatments) and in each date of sampling large seed was found to produce greater numbers of tubers per plant than small seed (Table 86). Greater numbers of tubers per plant from large seed might be related to the higher number of stems produced (Table 81 and 82).

(ii) Variety. The number of tubers recorded in both varieties for both seed sizes appeared to diminish with later dates of sampling and this effect seemed more marked in Majestic which tended to produce more tubers than Arran Pilot on the earlier two sampling dates (56 and 77 days after planting) but less on the final two dates (98 and 119 days after planting) [Table 86]. The reduction in tuber number during later stages of plant growth may be due to degeneration of small tubers on account of deflected translocation of carbohydrates towards large

TABLE 87

Effect of different storage treatments on the number of tubers per plant at different stages of growth in Arran Pilot (average of two seed sizes)

Storage Temperature	Without T.C.N.B.												With T.C.N.B.											
	d_1				d_2				d_3				d_1				d_2				d_3			
	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4
High (65°-80°F)	10.50	7.50	8.33	4.83	7.33	3.83	6.50	5.66	0.33	2.83	3.16	1.00	9.16	5.83	11.83	8.67	8.00	8.17	5.33	11.00	0.16	0	1.50	0
Medium (50°-60°F)	12.16	11.83	8.16	9.83	8.50	6.33	8.50	4.50	0.66	1.17	3.00	1.33	12.16	14.50	16.00	8.67	9.16	10.66	12.00	7.83	7.50	4.33	5.16	5.50
Low (40°F)	8.33	15.50	-	10.00	22.50	18.83	14.16	12,00	12.67	17.66	14.00	15.66	14.16	17.83	14.17	10.83	18.67	14.33	11.33	10.83	17.75	13.00	10.83	16.00

d_1 = Desprouted on 4.1.61
d_2 = " " 20.2.61
d_3 = " at the time of planting

l_1 = Lifted 56 days after planting
l_2 = " 77 " " "
l_3 = " 98 " " "
l_4 = " 119 " " "

tubers situated near the stem.

The effects of different storage treatments on the number of tubers per plant at different dates of lifting in Arran Pilot and Majestic may be conveniently considered separately.

Arran Pilot. With each desprouting treatment increase in temperature of storage before sprouting caused a decrease in the number of tubers per plant, irrespective of T.C.N.B. treatment. This adverse effect was more marked when the period of exposure was prolonged until February (d_2) or throughout the storage period (Table 87). Seeds stored at higher temperatures (medium and high) not only tended to form a smaller number of tubers on any date of lifting (Table 87), but also reduced the number of tubers between 3-5 cm. and over 5 cm. diameter in comparison with those stored at low temperature (Appendix 59). Seed tubers stored at higher temperature until planting time showed the most erratic behaviour in tuber formation and it has already been noted that mother tubers frequently produced tubers in the absence of top growth ('little potato') in many instances.

For seeds stored for varying periods at low temperature, it appeared that in Arran Pilot delay in sprouting (d_2) caused an increase in the number of tubers per plant at the earliest sampling date (56 days after planting) compared with those sprouted during January (d_1)

TABLE 88

Effect of T.C.N.B. treatment and time of sprouting on subsequent tuber formation in Arran Pilot

Time of Sprouting	Storage Treatment	Arran Pilot — Days after Planting: 56					77					98					119				
		Size Limits (cm.) of tubers				Total	Size Limits (cm.) of tubers				Total	Size Limits (cm.) of tubers				Total	Size Limits (cm.) of tubers				Total
		0-1	1-3	3-5	>5		0-1	1-3	3-5	>5		0-1	1-3	3-5	>5		0-1	1-3	3-5	>5	
January (4. 1.61)	Stored at 40°F without T.C.N.B.	3.0	1.99	3.17	0.17	8.33	3.00	5.33	6.67	0.50	15.50	1.16	6.00	7.33	1.33	15.82	0.33	1.84	6.50	1.33	10.00
	Stored at 40°F with T.C.N.B.	6.33	7.16	0.50	0.17	14.16	5.0	5.50	6.00	1.33	17.83	2.33	6.50	2.67	2.67	14.17	0.33	4.17	4.50	1.83	10.83
February (20.2.61)	Stored at 40°F without T.C.N.B.	12.83	9.50	0.17	-	22.50	5.67	4.34	8.50	0.32	18.83	1.50	3.50	7.33	1.83	14.16	0.50	3.00	6.50	2.00	12.00
	Stored at 40°F with T.C.N.B.	7.83	10.67	0.17	-	18.67	3.00	3.16	7.67	0.50	14.33	0.83	5.0	4.83	0.67	11.33	0.50	4.00	4.83	1.50	10.83
Unsprouted	Stored at 40°F without T.C.N.B.	6.00	6.67	-	-	12.67	5.67	6.16	5.83	-	17.66	0.33	5.17	6.16	2.34	14.00	0.50	5.16	6.83	3.17	15.66
	Stored at 40°F with T.C.N.B.	7.55	10.20	-	-	17.75	3.83	5.17	3.50	0.50	13.00	0.33	4.0	5.50	1.00	10.83	0.50	5.50	7.83	2.17	16.00

but later sampling dates (77, 98 and 119 days after planting) showed no marked differences between the two dates of sprouting (Table 88). With regard to tuber size, January sprouted seeds (irrespective of T.C.N.B. treatment) formed a larger number of tubers of higher diameter (3-5 cm. and over 5 cm.) than February sprouted seeds at the first sampling dates (56 days after planting) but the differences were less marked at later sampling dates (Table 88). There was no marked difference in tuber numbers per plant at different stages of plant development between unsprouted seeds (stored throughout at low temperature) and those sprouted during January (d_1) and February (d_2) from low temperature. This behaviour of tuber formation was found to a greater or lesser extent irrespective of T.C.N.B. treatment (Table 88). As regards tuber size, sprouted seed (January and February) formed a larger number of tubers between 3-5 cm. and over 5 cm. diameter than unsprouted seed (stored throughout at low temperature) up to 98 days after planting, but later (at the fourth sampling date, 119 days after planting) unsprouted seed gave a larger number of tubers of higher diameter (3-5 cm. and over 5 cm.) than sprouted seed (Table 88). It seems that sprouting before planting hastened early growth of tubers but there was no advantage from sprouting in the further growth of the tubers. This behaviour was found to a greater or lesser extent in both T.C.N.B. and no T.C.N.B. treatments.

TABLE 89

Effect of various storage temperatures with or without T.C.N.B. on subsequent tuber formation in Majestic

Storage Treatment until 4.1.61	Majestic																			
	Days after Planting																			
	56					77					98					119				
	Size Limits (cm.) of tubers				Total	Size Limits (cm.) of tubers				Total	Size Limits (cm.) of tubers				Total	Size Limits (cm.) of tubers				Total
	0-1	1-3	3-5	>5		0-1	1-3	3-5	>5		0-1	1-3	3-5	>5		0-1	1-3	3-5	>5	
Stored at 65°-80°F without T.C.N.B.	10.33	11.50	1.67	-	23.50	2.0	1.50	2.66	1.66	7.82	1.33	3.33	3.34	3.00	11.00	-	0.83	3.83	4.17	3.83
Stored at 50°-60°F without T.C.N.B.	4.66	11.50	1.17	-	17.33	5.17	4.83	5.50	0.33	15.83	2.0	2.84	4.66	3.33	12.83	0.17	1.83	4.00	3.33	9.33
Stored at 40°F without T.C.N.B.	8.33	8.00	0.17	-	16.50	7.0	5.33	4.50	1.67	18.50	1.66	4.50	3.67	3.00	12.83	0.16	1.66	1.50	4.34	7.67
Stored at 65°-80°F with T.C.N.B.	7.16	11.67	1.33	-	20.16	3.16	3.34	5.66	-	13.16	1.33	3.83	3.50	2.50	11.16	1.83	5.34	4.33	1.16	12.66
Stored at 50°-60°F with T.C.N.B.	7.0	7.50	0.17	-	14.67	2.33	3.67	3.83	0.67	10.50	0.83	2.83	4.50	2.17	10.33	0.33	2.00	2.84	1.66	6.83
Stored at 40°F with T.C.N.B.	4.50	9.16	0.34	-	14.00	3.67	2.00	4.16	1.17	11.00	1.17	2.17	4.66	3.33	11.33	0.67	1.66	2.0	3.83	8.10

There was no marked difference in the number of tubers per plant between T.C.N.B. and no T.C.N.B. treated seeds sprouted during January (d_1), February (d_2) or unsprouted seeds stored previously at low temperature (Table 88).

Majestic. Storage until January (4th January, i.e. d_1) at high and medium temperatures resulted in a greater number of tubers per plant at the first sampling date (56 days after planting) in comparison with low temperature storage, irrespective of T.C.N.B. treatment, but on subsequent dates of sampling, temperature of storage appeared to exert little effect (Table 89). With regard to growth of tubers, storage at medium and high temperature without T.C.N.B. gave rise to a larger number of tubers of higher diameter classes (3-5 cm. and over 5 cm.) up to 98 days after planting than those stored at low temperature, but later (on the fourth sampling date - 119 days after planting) seed stored at low temperature formed a greater number of tubers of higher diameter (over 5 cm.) compared with the medium and high temperature treatment (Table 89). In the case of T.C.N.B. treatments, high temperature gave more larger tubers at the first sampling date than low temperature storage, but subsequently the position was reversed. There was a general tendency for medium temperature storage with T.C.N.B. to give the lowest numbers of tubers of larger sizes at all sampling dates (Table 89).

TABLE 90

Effect of different storage treatments on the number of tubers per plant at different stages of plant growth in Majestic (average of two seed sizes)

Storage Temperature	Without T.C.N.B.												With T.C.N.B.											
	d_1				d_2				d_3				d_1				d_2				d_3			
	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4
High (65°-80°F)	23.50	7.83	11.00	8.33	5.00	6.00	4.66	3.00	2.33	3.83	2.67	2.16	20.16	13.16	11.16	12.66	6.33	8.33	4.16	2.00	1.50	0.66	2.33	4.00
Medium (50°-60°F)	17.33	15.83	12.83	9.33	12.33	15.83	7.66	8.83	5.00	6.83	3.66	2.33	4.67	10.50	10.33	6.83	0	6.16	3.00	2.16	0	0	1.33	1.50
Low (40°F)	16.50	18.50	12.83	7.66	22.50	16.33	10.83	13.33	6.83	20.17	16.83	10.67	14.00	11.00	11.33	8.17	15.16	11.33	11.00	8.50	17.83	17.00	17.83	15.00

d_1 = Desprouted on 4.1.61
d_2 = " " 20.2.61
d_3 = " at the time of planting

l_1 = Lifted 56 days after planting
l_2 = " 77 " " "
l_3 = " 98 " " "
l_4 = " 119 " " "

A depressing effect of medium and high temperature storage on the formation of tubers was evident when the period of exposure was prolonged until February (d_2) or throughout the storage period (d_3). On any date of sampling the total number of tubers (Table 90) as well as the number of tubers between 3-5 cm. and over 5 cm. (Appendix 59) was maximum for low temperature (regardless of T.C.N.B.), intermediate for medium temperature without T.C.N.B. and lowest for medium temperature with T.C.N.B. or high temperature (with or without T.C.N.B.).

Summarising the effect of time of sprouting on subsequent formation of tubers per plant after low temperature storage, irrespective of T.C.N.B. treatment, unsprouted seed (stored throughout) formed a larger number of tubers per plant than sprouted seed (January and February) from 77 days after planting (Table 91). When the numbers of tubers of higher diameter classes produced by sprouted (January and February) and unsprouted seed were compared, however, it was found that sprouted seed formed a greater number of tubers between 3-5 cm. at the first sampling date (56 days after planting) and over 5 cm. diameter on any sampling date than unsprouted seed (Table 91).

From the above result it seems that in Majestic when sprouted seed is planted, smaller numbers of main stems develop (Fig. 16 C and D) giving rise to a smaller number of tubers of relatively higher diameter (Table 91), whereas

TABLE 91

Effect of storage at 40°F on subsequent tuber formation in Majestic

Time of Sprouting	Storage Treatment	Majestic – Days after Planting: 56 – Size Limits (cm.) of tubers 0-1	56: 1-3	56: 3-5	56: >5	56: Total	77 – Size Limits (cm.) of tubers 0-1	77: 1-3	77: 3-5	77: >5	77: Total	98 – Size Limits (cm.) of tubers 0-1	98: 1-3	98: 3-5	98: >5	98: Total	119 – Size Limits (cm.) of tubers 0-1	119: 1-3	119: 3-5	119: >5	119: Total
January (4.1.61)	Stored at 40°F without T.C.N.B.	8.33	8.00	0.17	-	16.50	7.0	5.33	4.50	1.67	18.50	1.66	4.50	3.67	3.00	12.83	0.16	1.66	1.50	4.34	7.67
	Stored at 40°F with T.C.N.B.	4.50	9.16	0.34	-	14.00	3.67	2.00	4.16	1.17	11.00	1.17	2.17	4.66	3.33	11.33	0.67	1.66	2.00	3.83	8.16
February (20.2.61)	Stored at 40°F without T.C.N.B.	8.66	12.58	1.25	-	22.49	3.50	4.49	5.84	2.50	16.33	1.00	1.83	4.00	4.00	10.83	1.00	4.00	4.33	4.00	13.33
	Stored at 40°F with T.C.N.B.	5.50	8.33	1.00	-	15.16	1.67	3.50	4.83	1.33	11.33	0.50	3.84	3.33	3.33	11.00	0.17	1.83	2.50	4.00	8.50
Unsprouted	Stored at 40°F without T.C.N.B.	5.33	1.50	-	-	6.83	6.00	6.17	7.33	0.67	20.17	1.83	4.83	4.00	1.67	16.83	0.33	2.00	4.50	3.83	10.66
	Stored at 40°F with T.C.N.B.	9.66	8.00	0.17	-	17.83	4.00	6.33	6.17	0.50	17.00	2.66	5.50	9.17	1.00	17.83	1.00	4.50	6.33	3.17	15.00

when unsprouted seed is planted, a larger number of main stems develop (Fig. 16 C and D) and as a result a larger number of small size tubers are formed (Table 91). In this variety, it appeared that from sprouted seed the underground branches do not contribute to tuber formation to a large extent in contrast with Arran Pilot where underground branches played an important role in tuber production (Fig. 16 A and B).

In comparing T.C.N.B. and no T.C.N.B. treatment at low temperature, seed stored with T.C.N.B. and sprouted during January and February tended to form a smaller number of tubers per plant than comparable seed stored without T.C.N.B. (Table 91). In the case of unsprouted seed, i.e. stored throughout at low temperature, treatment with T.C.N.B. tended to cause a greater number of tubers per plant than that stored without T.C.N.B. (Table 91).

D. Yield of Tuber at Maturity

1. Total Yield (Tons/Acre)

The analysis of variance for the effect of variety, seed size and storage treatment on total yield at final harvest in October had been presented in Appendix 60. The variation between the replications, although significant, may be ignored as the experimental design was split split plot and the treatments were randomised in each replication, so that the variation between the replications equally affected all the treatments.

The effects of variety, date of desprouting, storage treatment and seed size and the interactions between variety and date of desprouting and storage treatment with variety and storage treatment with date of desprouting were significant. However, more detailed information of these effects may be obtained from consideration of the interaction of treatments, variety and date of desprouting (T x V x D) and treatment, variety and seed size (T x V x S) which were also significant (Appendix 60).

(a) Effect of Storage Treatment and Date of Desprouting on Tuber Yield in Arran Pilot and Majestic (T x V x D)

In view of the significant interaction variance between the effect of treatment and date of desprouting and variety, the effect of treatment and date of desprouting and their interaction may be discussed separately for the two varieties.

Arran Pilot

(i) The Main Effect of Storage Treatment (Average of Three Dates of Desprouting) in Arran Pilot

The main effect (average of three dates of desprouting) of storage treatment showed that an increase in the temperature of storage resulted in a significant reduction in tuber yield (Table 92). In the case of dusted seeds, those stored at low temperature yielded respectively 9.871 and 8.590 tons per acre more than that stored at high and medium temperature, and in the case of untreated (no T.C.N.B.) seeds the corresponding increases were 10.209 and 7.969 tons (Table 92) averaged for the three dates of desprouting. In comparing dusted with untreated (no T.C.N.B.) seeds, there was a tendency for untreated seeds to give higher yields at comparable temperatures of storage but the increase was only significant at the medium temperature level (Table 92).

(ii) The Main Effect of Date of Desprouting (Average of Storage Treatments) in Arran Pilot

The effect of date of desprouting (V x D) showed that in Arran Pilot delay in time of desprouting caused a significant reduction in tuber yield (Table 93), but this may be associated with the adverse effect of prolonged exposure at high and medium temperature, irrespective of T.C.N.B. treatment (Table 92).

Considering the effects of storage treatment for the

TABLE 92

Effect of storage treatment and date of desprouting on the yield of tubers (tons/acre) in Arran Pilot

Storage Temperature	Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65°-80°F)	11.514	7.096	7.057	8.555	11.602	11.681	0.911	8.065
Medium (50°-60°F)	16.010	12.064	4.312	10.795	13.763	10.148	4.126	9.346
Low (40°F)	18.505	18.507	19.281	18.764	18.836	17.680	17.292	17.936

S.E. of Treatment x Variety ± 0.474

S.E. of Treatment x Variety x Date of Desprouting ± 0.827

N.B. d_1 = Desprouted on 4.1.61

d_2 = Desprouted on 20.2.61

d_3 = Desprouted at the time of planting.

TABLE 93

Effect of date of desprouting on tuber yield (tons/acre) in Arran Pilot and Majestic

Variety	Date of Desprouting			Mean
	d_1	d_2	d_3	
Arran Pilot	15.038	12.862	8.830	12.247
Majestic	21.274	16.288	13.577	17.046

S.E. of Variety ± 0.533

S.E. of Variety x Date of Desprouting ± 0.360

N.B. d_1 = Desprouted on 4. 1.61
d_2 = Desprouted on 20. 2.61
d_3 = Desprouted at the time of planting.

different dates of desprouting, the effect of storage treatment on tuber yield may be explained more clearly.

(iii) Seed Tubers Stored until 4th January before Sprouting in Light

In January sprouted seeds (d_1) it may be noted that there was no significant difference in rate of plant emergence between the different storage treatments (Table 75 and 76). However, the yielding capacity of the plants was directly related to the previous storage condition of the mother tuber. Thus seed tubers stored at low temperature, irrespective of T.C.N.B., before sprouting in light gave significantly greater yields than those stored at high and medium temperature (Table 92). It seems that restricted growth of foliage and tuber production during plant development associated with high and medium temperature [observed previously in the plant growth studies (Table 77 and 78)] was reflected in reduced yield at final harvest (Table 92) and the adverse effect of medium and high storage temperature on final yield was aggravated with the higher temperature. In comparing T.C.N.B. and no T.C.N.B. treatments, differences at low and high temperature were not significant, whereas at medium temperature untreated seeds (no T.C.N.B.) gave significantly greater yield than those stored with T.C.N.B. (Table 92).

(iv) Seed Tubers Stored until 20th February before Sprouting in Light

The unfavourable effect of high and medium storage temperatures on tuber yield increased when the period of storage was prolonged until 20th February (d_2). Seeds stored at low temperature (irrespective of T.C.N.B.) until 20th February (d_2) yielded significantly greater than those stored at medium and high temperature (Table 92).

In February (d_2) sprouted seeds previously stored without T.C.N.B., it may be noted that storage at medium temperature gave a significantly greater yield than storage at high temperature (Table 92) and this higher yield in the former case may be associated with a higher final stand of plants (Table 74). In the case of T.C.N.B. treatment the difference in yield between these two temperatures was not significant (Table 92). In comparing T.C.N.B. and no T.C.N.B. treatments at high temperature, T.C.N.B. treated tubers yielded significantly greater than untreated seeds (Table 92) and again this may be related to higher plant stand in the former case (Table 74). At medium temperature T.C.N.B. exerted no significant effect on tuber yield (Table 92).

(v) Seed Tubers Planted Directly from Storage

The unfavourable effect of high and medium storage temperatures on tuber yield reached its maximum when seeds were stored throughout the storage period (d_3) and seeds stored at low temperature, irrespective of T.C.N.B., produced significantly higher yields than those stored at medium and high temperatures.

Seed tubers stored throughout (d_3) the storage period without T.C.N.B. at high temperature gave a higher plant stand (Table 74) and also yielded significantly greater than untreated seeds stored at medium temperature (Table 92). In the case of T.C.N.B. treatment the position of the two temperature treatments with respect to yield was reversed (Table 92). In considering T.C.N.B. and no T.C.N.B. treatment, only at high temperature did untreated seeds yield significantly greater than treated tubers (Table 92) and again this result is associated with a higher plant stand in the former case (Table 74).

(vi) Seed Tubers Stored at Low Temperature before Sprouting or Planting

Summarising the effect of time of sprouting on subsequent yield of tubers per acre after low temperature storage, irrespective of T.C.N.B. treatment, sprouting before planting (January and February) did not show any significant increase in final yield over that of seeds planted direct from cold storage. Although the difference in yield between sprouted and unsprouted seeds was not significant, it may be noted in Table 92 that in the case of untreated seeds (no T.C.N.B.) unsprouted seeds showed a tendency to yield more (0.7 tons per acre) than sprouted seeds (January and February) and in the case of T.C.N.B. treatment unsprouted seeds tended to yield less than January (1.5 tons per acre) and February (0.4 tons per acre) sprouted seeds. In comparing T.C.N.B. and no T.C.N.B. treatment, the difference in yield between treated and untreated seeds, irrespective of period of storage, was not significant; however, seed tubers stored throughout without T.C.N.B. tended to give a greater yield (1.989 tons per acre) than comparable seed tubers stored with T.C.N.B. (Table 92).

Majestic

(i) The Main Effect of Storage Treatment (Average of Three Dates of Desprouting) in Majestic

The main effect (average of three dates of desprouting)

TABLE 94

Effect of storage treatment and date of desprouting on tuber yield (tons/acre) in Majestic

Storage Temperature	Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65°–80°F)	22.165	13.072	9.452	14.896	20.594	12.845	5.778	13.006
Medium (50°–60°F)	23.628	19.674	15.610	19.637	9.572	2.496	3.668	5.246
Low (40°F)	25.055	24.673	23.125	24.284	26.629	24.966	24.032	25.209

S.E. of Treatment x Variety ± 0.474

S.E. of Treatment x Variety x Date of Desprouting ± 0.827

N.B. d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting.

of storage treatment showed that in Majestic T.C.N.B. treatment notably modified the effect of temperature. In seed tubers stored without T.C.N.B., the variety responded similarly to Arran Pilot, an increase in storage temperature causing a significant reduction in yield (Table 94). However, for seed stored with T.C.N.B. those held at medium temperature yielded significantly less than those stored at high temperature, although low temperature storage continued to give the highest yield. Thus there was a marked reduction in yield at medium temperature storage when T.C.N.B. was applied. A significant, but smaller reduction in yield was also found at high temperature storage where T.C.N.B. was applied, but T.C.N.B. had no effect at low temperature (Table 94).

Yields of Majestic were significantly greater than those of Arran Pilot for comparable storage treatments with the exception of storage with T.C.N.B. at medium temperature which had a particularly adverse effect on yield in Majestic (Table 92 and 94).

(ii) <u>The Main Effect of Date of Desprouting (Average of Storage Treatment) in Majestic</u>

The effect of time of desprouting showed that delay in time of desprouting before sprouting in light caused a significant reduction in yield (Table 93) and this reduction in yield was mainly associated with prolonged exposure to high and medium temperatures before sprouting until February (d_2) and reached its maximum when seeds were planted directly from storage (d_3) [Table 94].

More detailed consideration of the effect of storage treatment on yield is obtained from separate discussion for the different dates of desprouting.

(iii) <u>Seed Tubers Stored until 4th January before Sprouting in Light</u>

It was found (Table 89 and Fig. 14 A) that with the shorter storage period until January (d_1) medium and high temperature storage without T.C.N.B. hastened early tuber production, but at the final lifting seeds stored at low temperature gave a higher yield than those stored at medium temperature and significantly higher yields than high temperature treatment (Table 94). In considering the relative effect of high, medium and low temperatures without T.C.N.B. for short period (4th January) it may be noted that in Majestic the increases in yield from low temperature storage compared with medium and high temperature were 1.4 tons (not significant) and 2.8 tons per acre (significant) respectively (Table 94), whereas in Arran Pilot the corresponding increases were 2.5 tons (significant) and 6.8 tons per acre (significant) [Table 92]. It seems that Majestic is relatively less susceptible to the adverse effect of higher temperature than Arran Pilot and this may be related to its slower rate of sprout production.

In the case of seeds stored with T.C.N.B. until January (d_1) low temperature storage gave a significantly greater yield than storage at high and medium temperature. The adverse effect of T.C.N.B. at higher temperature had also been noted in the plant growth study (Fig. 14 B) and also gave incomplete plant stand (Table 74). In comparing T.C.N.B. and no T.C.N.B., only following medium temperature storage were untreated seeds found to give significantly greater yields than comparable seeds stored with T.C.N.B. (Table 94) and again this may be related to the higher plant stand in the former case (Table 74). At low and high temperature treatment the differences between T.C.N.B. and no T.C.N.B. treatments were not significant (Table 94).

(iv) Seed Tubers Stored until 20th February (d_2) before Sprouting in Light

Seeds stored at low temperature, irrespective of T.C.N.B. treatment, until February (d_2) yielded significantly greater than those stored at high and medium temperature.

In February (d_2) sprouted seeds it may be noted that undusted seeds previously stored at medium temperature gave a significantly greater tuber yield than high temperature treatment, whereas in the case of T.C.N.B. treated seeds the effect of the two temperatures was opposite (Table 94) and again this may derive from differences in plant stand (Table 74). In comparing

T.C.N.B. and no T.C.N.B. treatments, only at medium temperature did untreated seeds give a significantly greater yield than dusted seeds, but the differences between low and high temperature treatments were not significant. (Table 94).

(v) Seed Tubers Planted Directly from Storage

The unfavourable effect of high and medium storage temperatures on tuber yield reached its maximum when seed tubers were stored throughout the storage period (d3) and seeds stored at low temperature, irrespective of T.C.N.B. treatment, continued to give significantly greater yields than those stored at high and medium temperature. Also it may be noted that seeds stored at medium temperature without T.C.N.B. gave a significantly greater yield than those stored at high temperature and in the case of T.C.N.B. treatment the effect of the two temperatures was opposite (Table 94).

In comparing T.C.N.B. and no T.C.N.B. treatment, at medium and high temperature, untreated (without T.C.N.B.) seeds yielded significantly higher than treated seeds (Table 94) and again this may be associated with the higher plant stand from untreated seeds (Table 74). At low temperature the difference in yield between T.C.N.B. and no T.C.N.B. was not significant (Table 94).

(vi) Seed Tubers Stored at Low Temperature before Sprouting or Planting

In comparing the final yield of sprouted (January and February) and unsprouted seeds (d_3) when all seed tubers were stored at low temperature, sprouted seeds gave in general higher yields than unsprouted, irrespective of T.C.N.B. treatment, but the increase was only significant in the case of January sprouted seeds (d_1) stored previously with T.C.N.B. (Table 94). No significant difference in yield was found between January and February sproutings, irrespective of T.C.N.B. treatment, but there was a slight tendency for higher yields from earlier sprouting (Table 94).

It may be further noted that while in Arran Pilot seed tubers stored throughout at low temperature with or without T.C.N.B. produced a significantly greater yield than those stored at high and medium temperature without T.C.N.B. until 4th January (Table 92), in the case of Majestic the differences were not significant (Table 94). This result indicates that Majestic is less susceptible to the adverse effects of higher temperature than Arran Pilot and this may be related to the slower rate of sprout production in the former variety.

(b) <u>Effect of Treatment and Size of Seed Tuber on Yield in Arran Pilot and Majestic (T x V x S)</u>

The main effect of seed size showed that in both varieties large seed produced a significant increase in yield over small seed (Table 95), but this size effect did not apply to all treatments and was reversed in the case

TABLE 95

Effect of seed size on the yield of tubers (tons/acre) in Arran Pilot and Majestic

Variety	Large Seed	Small Seed
Arran Pilot	12.744	11.743
Majestic	17.494	16.599

S.E. of Variety x Seed Size ± 0.294

of Majestic stored at medium temperature with T.C.N.B. and in the case of Arran Pilot stored at high temperature with T.C.N.B. (Table 96).

In Arran Pilot large seed at low temperature without T.C.N.B. and at medium temperature with T.C.N.B. gave significantly greater yields than small seed, but in other treatments no significant difference between the two seed sizes were found. In Majestic, only at high temperature with T.C.N.B. did large seed yield significantly greater than small seed (Table 96).

It seems that the additive effect of higher yield in different treatments in favour of large seed made the difference significant between the two seed sizes.

TABLE 96

Effect of treatment and seed size on the yield of tubers (tons/acre) in Arran Pilot and Majestic (T x V x S)

Storage Temperature	Arran Pilot				Majestic			
	Without T.C.N.B.		With T.C.N.B.		Without T.C.N.B.		With T.C.N.B.	
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed
High (65^{o}-80^{o}F)	8.778	8.333	7.221	8.909	15.710	14.082	14.806	11.206
Medium (50^{o}-60^{o}F)	11.513	10.777	10.795	7.897	19.884	19.390	4.082	6.409
Low (40^{o}F)	20.036	17.492	18.119	17.752	24.615	23.954	25.865	24.553

S.E. of Treatment x Variety x Seed Size ± 0.675

2. Total Number of Tubers (1000/Acre)

The analysis of variance for the effect of variety, seed size and storage treatment on total number of tubers at final harvest in October has been shown in Appendix 65.

The effects of variety, date of desprouting, seed size, treatment and the interactions between date of desprouting with seed size, variety with date of desprouting, variety with seed size and date of desprouting, variety with treatment, treatment with date of desprouting, treatment with seed size, treatment with variety, seed size and date of desprouting were significant. More detailed information on these effects may be obtained from the consideration of the interactions of treatment, variety and date of desprouting (T x V x D) and treatment, variety and seed size (T x V x S) which were also significant (Appendix 65).

(a) Effect of Treatment and Date of Desprouting on Tuber Number in Arran Pilot and Majestic (T x V x D)

A significant interaction variance of storage treatment, variety and date of desprouting indicates that varieties responded differently with treatment and date of desprouting. To explain the interaction of the effect of storage treatment and date of desprouting on the number of tubers, varieties may be discussed separately in this study.

Arran Pilot

(i) The Main Effect of Storage Treatment (Average of Three Dates of Desprouting) in Arran Pilot

The main effect (average of three dates of desprouting) of storage treatment showed that irrespective of T.C.N.B. treatment an increase in the temperature of storage caused a significant decrease in the number of tubers per acre. In the case of dusted (T.C.N.B.) seed that stored at low temperature yielded 108.04 and 83.84 thousands per acre more than those stored respectively at high and medium temperature and in the case of untreated (no T.C.N.B.) seed the corresponding increases were 99.86 and 77.86 thousands per acre (Table 97) averaged for the three dates of desprouting. There was no significant difference in total number of tubers per acre between treated and untreated seed at low, medium and high temperature treatment averaged for three dates of desprouting (Table 97).

(ii) <u>The Main Effect of Date of Desprouting (Average of Storage Treatments) in Arran Pilot</u>

The main effect of date of desprouting (average of all storage treatments) showed that longer periods of storage before sprouting until February (d_2) or throughout (d_3) caused a significant reduction in the numbers of tubers produced (Table 98). This reduction was, however, mainly associated with longer periods of storage at high and medium temperatures, irrespective of T.C.N.B. treatment (Table 97).

The effect of storage treatment on the number of tubers produced per acre may be explained more fully by

TABLE 97

Effect of treatment and date of desprouting on the number of tubers (1000/acre) in Arran Pilot

Storage Temperature	Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65°-80°F)	157.76	104.70	75.50	112.66	166.66	152.14	11.94	110.24
Medium (50°-60°F)	198.44	153.27	52.27	134.66	192.47	152.46	58.40	134.44
Low (40°F)	207.96	221.19	208.44	212.53	238.29	212.96	203.60	218.28

S.E. of Treatment x Variety ± 4.82

S.E. of Treatment x Variety x Date of Desprouting ± 8.37

N.B. d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting.

discussing their effects for the different dates of desprouting separately.

TABLE 98

Effect of date of desprouting on the number of tubers (1000/acre) in Arran Pilot and Majestic

Variety	Date of Desprouting			Mean
	d_1	d_2	d_3	
Arran Pilot	193.60	166.12	101.69	153.80
Majestic	141.25	108.60	104.76	118.20

S.E. of Variety ±4.29

S.E. of Variety x Date of Desprouting ±4.35

d_1 = Desprouted on 4. 1.61
d_2 = Desprouted on 20. 2.61
d_3 = Desprouted at the time of planting.

(iii) Seed Tubers Stored until 4th January before Sprouting in Light

In the case of seeds sprouted during January (d_1), increase in storage temperature from low to medium or to high before sprouting in light caused a decrease in the number of tubers produced per acre. The decrease in the number of tubers associated with increase in temperature of storage was significant in the case of T.C.N.B. treatment (Table 97), whereas in untreated seeds the difference between low and medium temperature in favour of low temperature was not significant, but both of these storage treatments produced significantly greater numbers of tubers per acre than those stored at high temperature (Table 97). This decrease associated with increase in storage temperature may be attributed to decrease in the stem numbers per acre (Table 85). In comparing T.C.N.B. and no T.C.N.B. treatment, the differences at high and medium temperature were not significant, whereas at low temperature T.C.N.B. treated seed gave a significantly greater number of tubers per acre compared with that stored without T.C.N.B. (Table 97) derived from the greater number of stems per acre in the former case (Table 85).

The adverse effect of high and medium temperature, irrespective of T.C.N.B. treatment, on the number of tubers produced per acre increased, when the period of exposure was prolonged until February (d_1) and was greatest when seed was stored throughout the storage period (d_3). Seed stored at low temperature, irrespective of T.C.N.B. treatment, until February or throughout gave a significantly greater number of tubers per acre than that stored at medium and high temperatures (Table 95).

(iv) Seed Tubers Stored until 20th February before Sprouting in Light

It may be noted in February sprouted seed (d_2) that seed stored without T.C.N.B. at medium temperature formed a significantly greater number of tubers per acre than those stored at high temperature (Table 97) which may be attributed to the higher plant stand (Table 74) and also to the greater number of stems per acre (Table 85). In the case of T.C.N.B. treatment the differences in the number of tubers produced (Table 97) and also in the number of stems per acre (Table 85) between these two temperatures was not significant. In comparing T.C.N.B. and no T.C.N.B. treatment at high temperature, treated seed produced a significantly greater number of tubers than untreated seed (Table 97) which is again related to a higher final plant stand in the former case (Table 74). At medium temperature there was no significant difference in the tuber number per acre between T.C.N.B. and no T.C.N.B. treatments.

(v) <u>Seed Tubers Planted Directly from Storage</u>

Seeds planted directly from storage at high temperature without T.C.N.B. gave a higher plant stand (Table 74) and also formed a significantly greater number of tubers per acre than untreated seed stored at medium temperature (Table 97). In the case of T.C.N.B. treatment the position of the two temperature treatments in the number of tubers produced per acre was reversed (Table 97). In considering T.C.N.B. and no T.C.N.B. treatment, only at high temperature did untreated seed give a significantly greater number of tubers per acre than treated seed (Table 97).

(vi) Seed Tubers Stored at Low Temperature before Sprouting or Planting

Summarising the effect of time of sprouting after low temperature storage in the case of no T.C.N.B. treatment there was no significant difference in the number of tubers produced per acre between January sprouted (d_1), February sprouted (d_2) and unsprouted seed (d_3). However, February (d_2) sprouted seed tended to give more tubers than January sprouted (d_1) and unsprouted seed. On the other hand, in the case of T.C.N.B. treatment, sprouted seed (January and February) formed a greater number of tubers than unsprouted seed (d_3) and the difference in favour of January sprouting was significant (Table 97). It seems from the above result that sprouted seed, in spite of producing a smaller number of main stems, gave a larger number of tubers than unsprouted seed and this may be related to the greater number of underground branches able to produce tubers in the former case (Fig. 16 A and B). In comparing T.C.N.B. and no T.C.N.B. treatment at low temperature, seed stored with T.C.N.B. until January (d_1) produced a significantly greater number of tubers than that stored without T.C.N.B. (Table 97) and it may be related to a greater number of stems per plant or per acre in the former case (Table 84 and 85). The differences between T.C.N.B. and no T.C.N.B. treatments in the number of tubers per acre was not significant when seed was sprouted on 20th February (d_2) or stored throughout the storage period (d_3) [Table 97].

Majestic

(i) The Main Effect of Storage Treatment (Average of Three Dates of Desprouting) in Majestic

The main effect of storage treatment (average of three dates of desprouting) showed that in Majestic T.C.N.B. treatment markedly modified the effect of temperature. Majestic seed stored without T.C.N.B. responded similarly to Arran Pilot, an increase in storage temperature causing a significant reduction in the number of tubers produced per acre (Table 99). However, in the case of T.C.N.B. treatment, seed stored at high temperature produced a significantly greater number of tubers than that stored at medium temperature, while low temperature storage continued to give the highest number of tubers per acre. Thus there was a marked reduction in the numbers of tubers following medium temperature storage when T.C.N.B. was applied. After high and low temperature storage there was no significant difference in the numbers of tubers produced per acre from T.C.N.B. treated and untreated seed (Table 99).

TABLE 99

Effect of treatment and date of desprouting on the number of tubers (1000/acre) in Majestic

Storage Temperature	Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65^o-80^oF)	138.42	90.02	72.11	100.19	165.37	109.71	55.98	110.35
Medium (50^o-60^oF)	158.11	120.35	94.06	124.17	59.53	17.42	25.65	34.20
Low (40^oF)	158.27	162.30	181.98	167.52	167.79	151.81	198.76	172.79

S.E. of Treatment x Variety ± 4.82

S.E. of Treatment x Variety x Date of Desprouting ± 8.37

N.B. d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting.

(ii) The Main Effect of Date of Desprouting (Average of Storage Treatments) in Majestic

The effect of time of desprouting (average of all storage treatments) indicated that delay in time of desprouting until February (d_2) caused a significant reduction in tuber number per acre and further delay until planting time (d_3) did not give a significant reduction (Table 98).

The effect of date of desprouting may be explained more fully by discussing separately the date of desprouting with storage treatment.

(iii) Seed Tubers Stored until 4th January before Sprouting in Light

It may be noted in January sprouted seed (d_1) that seed stored without T.C.N.B. at high, medium and low temperature did not show any significant difference in the number of tubers produced per acre. In the case of T.C.N.B. treatment, the difference in tuber number between high and low temperature treatment was not significant and both gave a significantly greater number of tubers per acre than from seed stored at medium temperature (Table 99). In comparing T.C.N.B. and no T.C.N.B. treatment, seed stored at high and low temperature with T.C.N.B. was found to give a greater number of tubers per acre than untreated seed and the difference at high temperature in favour of T.C.N.B. treatment was significant (Table 99): on the other hand, at medium temperature seed stored without T.C.N.B. produced a significantly greater number of tubers (Table 99) and also showed a higher plant stand (Table 74) than seed stored with T.C.N.B.

The unfavourable effect of high and medium temperature on the number of tubers produced per acre increased when the period of exposure was prolonged until February (d_2) and reached its maximum when tubers were stored throughout the storage period (d_3). Seed stored at low temperature, irrespective of T.C.N.B. until February (d_2) or throughout (d_3) gave a significantly greater number of tubers per acre than that stored at medium and high temperature (Table 99).

(iv) Seed Tubers Stored until 20th February before Sprouting in Light

In February sprouted seed it may be noted that seed stored without T.C.N.B. at medium temperature gave a significantly greater number of tubers per acre (Table 99) and also had a greater plant stand (Table 74) than that stored at high temperature, whereas in the case of T.C.N.B. treatment the position of these two temperature treatments was reversed (Table 99). In comparing T.C.N.B. and no T.C.N.B. treatment, only at medium temperature did untreated (no T.C.N.B.) seed give a significantly greater number of tubers (Table 99) and produced higher plant stands (Table 74) than that stored with T.C.N.B. and the differences between them at high and low temperature were not significant (Table 99).

(v) Seed Tubers Planted Directly from Storage

In the case of seeds planted directly from storage, seed stored at medium temperature without T.C.N.B. produced a greater number of tubers (Table 99) and also had higher plant stand (Table 74) than that stored at high temperature and the position between these two temperature treatments in tuber number per acre was reversed when seed was stored with T.C.N.B. (Table 99). In comparing T.C.N.B. and no T.C.N.B. treatment, at high and low temperature the difference in the numbers of tubers per acre between T.C.N.B. and no T.C.N.B. was not significant, whereas at medium temperature untreated seed (no T.C.N.B.) gave a significantly greater number of tubers than treated seed (Table 99).

(vi) Seed Tubers stored at Low Temperature before Sprouting or Planting

Summarising the effect of time of sprouting on subsequent numbers of tubers per acre after low temperature storage, irrespective of T.C.N.B. treatment, sprouted seed (January and February) formed a significantly smaller number of tubers per acre than unsprouted seed (i.e. stored throughout at low temperature), but the difference in tuber numbers between January and February sprouted seed was not significant (Table 99). The greater number of tubers per acre from unsprouted seed compared with sprouted seed (sprouted during January and February from low temperature) may be related to a larger number of main stems in the former case, whereas the formation of underground branches capable of producing tubers was not so extensive in sprouted Majestic seed compared with Arran Pilot (Fig. 16 C and D). In this variety maximum number of tubers per acre was produced when seed was stored throughout at low temperature with T.C.N.B. (Table 99).

(b) Effect of Treatment and Size of Seed Tuber on the Number of Tubers Produced per Acre in Arran Pilot and Majestic (T x V x S)

The main effect of seed size (storage treatment averaged) showed that in both varieties large seed produced a significantly greater number of tubers than small seed (Table 100), but this size effect did not apply to all

TABLE 100

Effect of Size of seed on the number of tubers (1000/acre) in Arran Pilot and Majestic

Variety	Large Seed	Small Seed
Arran Pilot	161.92	145.68
Majestic	127.04	109.37

S.E. of Variety x Seed Size ±3.55

TABLE 101

Effect of treatment and seed size on the number of tubers (1000/acre) in Arran Pilot and Majestic

Storage Temperature	Arran Pilot				Majestic			
	Without T.C.N.B.		With T.C.N.B.		Without T.C.N.B.		With T.C.N.B.	
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed
High (65^{o}-80^{o}F)	117.23	108.09	92.60	127.88	109.81	90.56	126.81	93.89
Medium (50^{o}-60^{o}F)	144.12	125.19	158.86	110.03	129.60	118.74	24.41	43.99
Low (40^{o}F)	224.04	201.02	234.68	210.88	181.66	153.37	189.94	155.63

S.E. of Treatment x Variety x Seed Size ± 6.84

treatments and was reversed in the case of Majestic stored at medium temperature with T.C.N.B. and with Arran Pilot stored at high temperature with T.C.N.B. (Table 101).

In Arran Pilot large seed stored at low temperature regardless of T.C.N.B. and at medium temperature with T.C.N.B. gave a significantly greater number of tubers than small seed, but in other treatments no significant difference between the two seed sizes was found (Table 101).

In Majestic large seed stored at high and low temperature regardless of T.C.N.B. gave a significantly greater number of tubers per acre than small seed (Table 101).

It seems from the above results that the advantage from large seed in producing greater tuber numbers per acre was not evident after unfavourable storage conditions.

3. Yield (Tons/Acre) and Number (1000/Acre) of Ware (Over $2\frac{1}{4}$")

The analysis of variance of yield and number of ware has been presented respectively in Appendix 70 and Appendix 71.

The effects of variety, date of desprouting, storage treatment and the interactions between variety with date of desprouting, treatment with date of desprouting on yields and numbers of ware were significant. More detailed information of these effects may be obtained from the consideration of the interaction of storage treatment, variety and date of desprouting (T x V x D) which was also significant (Appendix 70 and Appendix 71).

Effect of Storage Treatment and Date of Desprouting on the Yield and the Number of Ware in Arran Pilot and Majestic (T x V x D)

As varieties differed significantly regarding storage treatment and date of desprouting they are discussed separately in order to explain the interaction of the effect of storage treatment and date of desprouting on the yield and number of ware.

Arran Pilot

(i) The Main Effect of Storage Treatment (Average of Three Dates of Desprouting) in Arran Pilot

The main effect of storage treatment (average of three dates of desprouting) showed that seed stored at low

TABLE 102

Effect of storage treatment and date of desprouting on the yield of ware (tons/acre) in Arran Pilot

Storage Temperature	Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65°-80°F)	3.636	2.268	2.988	2.964	3.240	3.510	0.342	2.364
Medium (50°-60°F)	4.662	4.218	1.566	3.480	3.294	3.186	1.260	2.580
Low (40°F)	5.454	3.762	5.472	4.896	4.122	3.672	4.032	3.942

S.E. of Treatment x Variety ± 0.405

S.E. of Treatment x Variety x Date of Desprouting ± 0.702

N.B. d_1 = Desprouted on 4.1.61

d_2 = Desprouted on 20.2.61

d_3 = Desprouted at the time of planting.

TABLE 103

Effect of storage treatment and date of desprouting on the number of ware (1000/acre) in Arran Pilot

Storage Temperature	Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65°-80°F)	11.94	8.07	10.49	10.16	12.42	12.74	0.97	8.71
Medium (50°-60°F)	15.97	15.81	5.97	12.58	12.42	11.24	3.71	9.14
Low (40°F)	23.23	15.65	22.42	20.43	16.62	16.78	17.10	16.83

S.E. of Treatment x Variety ±1.35

S.E. of Treatment x Variety x Date of Desprouting ±2.33

N.B. d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting.

TABLE 104

EFFECT OF DATE OF DESPROUTING ON THE YIELD OF WARE (TONS/ACRE) IN ARRAN PILOT AND MAJESTIC

Variety	Date of desprouting			Mean
	d_1	d_2	d_3	
Arran Pilot	4.068	3.435	2.610	3.371
Majestic	13.227	10.24[illegible]	6.055	10.108

S.E. of Variety ± 0.276
S.E. of Variety x Date of desprouting ± 0.263

TABLE 105

EFFECT OF DATE OF DESPROUTING ON THE NUMBER OF WARE (1000/acre) IN ARRAN PILOT AND MAJESTIC

Variety	Date of desprouting			Mean
	d_1	d_2	d_3	
Arran Pilot	15.43	13.39	10.11	12.98
Majestic	46.52	34.66	24.76	35.31

S.E. of Variety ± 1.15
S.E. of Variety x Date of desprouting ± 0.85

N.B.

d_1 = desprouted on 4.1.61
d_2 = " " 20.2.61
d_3 = " at the time of planting.

temperature, irrespective of T.C.N.B. treatment, gave a significantly greater yield and number of ware per acre than that stored at high and medium temperature (Table 102 and 103). Seed stored at medium temperature with or without T.C.N.B. tended to give a greater yield and number of ware than that stored at high temperature, but the increases were not significant (Table 102 and 103). There was no significant difference between T.C.N.B. treated and untreated seed in yield and number of ware at either high, medium or low temperatures of storage (Table 102 and 103).

(ii) The Main Effect of Date of Desprouting (Average of Storage Treatments) in Arran Pilot

The effect of date of desprouting (average of all treatments) indicated that seed tubers desprouted in January (d_1) and February (d_2) produced significantly larger yields and greater numbers of ware than those planted directly (d_3) from storage, but the difference between January (d_1) and February (d_2) sprouted seeds was not significant (Table 104 and 105). January (d_1) sprouted seed did, however, tend to give a greater yield and number of ware than February sprouted seed.

The effect of date of desprouting may be explained in more detail by discussing separately the three dates of desprouting with storage treatments.

With high temperature storage without T.C.N.B. no significant difference in yield and number of ware was found between January, February and unsprouted seeds. In the case of storage with T.C.N.B., at high temperature the difference in yield and number of ware between January and February sprouting was not significant, but both of these treatments produced a significantly greater amount of ware (yield and number) than those stored throughout (d_3) [Table 102 and 103].

Seed tubers stored at medium temperature, regardless of T.C.N.B. treatment, until January (d_1) and February (d_2) gave a significantly greater yield and number of ware than those planted directly from storage (d_3), but again the difference between January (d_1) and February (d_2) sprouting was not significant (Table 102 and 103).

At low temperature, irrespective of T.C.N.B. treatment, there was no significant difference between sprouted (January and February) unsprouted (stored throughout at low temperature) seed (Table 102 and 103).

(iii) Seed Tubers Stored until 4th January before Sprouting in Light

In considering the effect of different storage treatments at a particular date of desprouting on yield and number of ware, it may be seen in Table 102 that storage until January (d_1) without T.C.N.B. at high and medium temperatures did not result in a significant reduction in the yield (tons per acre) of ware compared with storage at low temperature. However, seeds stored at low temperature gave a significantly greater number of ware than those stored at high and medium temperatures (Table 103). In the case of T.C.N.B. treatment until January (d_1), the differences in yield (Table 102) and number (Table 103) of ware from high, medium and low temperature were not significant. In comparing T.C.N.B. and no T.C.N.B. treatment, the effect of treatment was not significant at high and medium temperature storage (Table 102 and 103), after low temperature storage the difference in yield between T.C.N.B. and no T.C.N.B. was not significant (Table 102), but untreated (without T.C.N.B.) seeds gave a significantly greater number of ware than those stored with T.C.N.B. (Table 103).

(iv) <u>Seed Tubers Stored until 20th February before Sprouting in Light</u>

For seed tubers stored until February (d_2) without T.C.N.B., storage temperature did not show any significant effect on yield of ware (Table 102). However, seeds stored at medium and low temperature gave a significantly greater number of ware than those stored at high temperature (Table 103). In the case of T.C.N.B. treatment until February (d_2), seeds stored at high, medium and low temperatures did not show any significant difference either in yield or number of ware (Table 102 and 103). At high, medium and low temperature the difference in yield (Table 102) and number (Table 103) of ware between T.C.N.B. and no T.C.N.B. treatment was not significant.

(v) Seed Tubers Planted Directly from Storage

Seed tubers planted directly from storage at low temperature, irrespective of T.C.N.B. treatment, gave a significantly greater yield and number of ware than those stored at high and medium temperature, but the difference between high and medium temperature both in yield and number was not significant (Table 102 and 103). In comparing T.C.N.B. and no T.C.N.B. treatment at high temperature, untreated (no T.C.N.B.) seeds produced a significantly greater yield and number of ware than treated seeds, but no significant effect from T.C.N.B. on yield and number of ware was found at medium and low temperatures (Table 102 and 103).

Majestic

(i) The Main Effect of Storage Treatment (Average of Three Dates of Desprouting) in Majestic

The main effect of storage treatment (average of date of desprouting) indicated that in Majestic the effect of temperature is notably modified by T.C.N.B. treatment. In tubers stored without T.C.N.B., the variety responded similarly to Arran Pilot, an increase in storage temperature resulting in a significant reduction in yield and number of ware (Table 106 and 107). However, for seeds stored with T.C.N.B. those held at medium temperature gave a significantly smaller yield and number of ware than those stored at high temperature, while low

TABLE 106

Effect of storage treatment and date of desprouting on the yield of ware (tons/acre) in Majestic

Storage Temperature	Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65°-80°F)	14.544	7.902	5.292	9.246	10.044	6.624	2.268	6.312
Medium (50°-60°F)	14.256	13.248	10.584	12.696	6.588	1.548	1.980	3.372
Low (40°F)	16.506	15.696	11.682	14.628	17.424	16.434	9.324	14.394

S.E. of Treatment x Variety ± 0.405

S.E. of Treatment x Variety x Date of Desprouting ± 0.702

N.B. d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting.

TABLE 107

Effect of storage treatment and date of desprouting on the number of ware (1000/acre) in Majestic

Storage Temperature	Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65^o–80^oF)	51.63	24.68	18.39	31.57	36.62	22.42	7.42	22.16
Medium (50^o–60^oF)	52.43	45.66	33.39	43.83	18.55	3.71	5.81	9.36
Low (40^oF)	58.40	56.14	46.46	53.67	61.47	55.34	37.11	51.30

S.E. of Treatment x Variety ± 1.35

S.E. of Treatment x Variety x Date of Desprouting ± 2.33

N.B. d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting.

temperature storage continued to give the highest yield (Table 106 and 107). In comparing T.C.N.B. and no T.C.N.B. treatment, at high and medium temperature, untreated seeds produced a significantly greater yield and number of ware than treated seeds, but no significant effect from T.C.N.B. was found at low temperature (Table 106 and 107).

Irrespective of T.C.N.B. and temperature of storage, Majestic formed a greater amount of ware (yield and number) than Arran Pilot (Table 104 and 105), but a significant difference in favour of Majestic for higher yield of ware was found at high and low temperature, regardless of T.C.N.B. treatment, and at medium temperature without T.C.N.B. (Appendix 74).

(ii) <u>The Main Effect of Date of Desprouting (Average of Storage Treatment) in Majestic</u>

The effect of date of desprouting (average of all treatments) showed that in Majestic delay in time of desprouting caused a significant reduction in the yield and number of ware (Table 104 and 105). This reduction was mainly associated with prolonged exposure to high and medium temperatures (Table 106 and 107).

The effect of date of desprouting may be explained in more detail by discussing separately the three dates of desprouting with storage treatment.

With high temperature storage, irrespective of

T.C.N.B. treatment, delay in desprouting caused a significant reduction in yield and number of ware. Thus maximum amount of ware (yield and number) was found in January (d_1) intermediate in February (d_2) and lowest in those planted directly from storage (Table 106 and 107).

Seeds stored at medium temperature without T.C.N.B. until January (d_1) and February (d_2) gave a significantly greater yield and number of ware than those planted directly from storage, but again the difference between January (d_1) and February (d_2) sprouting was not significant. However, January sprouted seeds gave a significantly greater number of ware than those sprouted during February. In the case of T.C.N.B. treatment at medium temperature, January (d_1) sprouted seeds gave a significantly greater yield and number of ware than February (d_2) and unsprouted seeds, but the difference between February and unsprouted seeds was not significant (Table 106 and 107).

At low temperature, irrespective of T.C.N.B. treatment, there was no significant difference between January (d_1) and February sprouted seeds. January (d_1) sprouted seed did, however, tend to give a greater yield and number of ware than February sprouted seed and both dates of sprouting (irrespective of T.C.N.B.) gave significantly greater yield and number of ware than those planted directly from cold storage (Table 106 and 107).

(iii) <u>Seed Tubers Stored until 4th January before Sprouting in Light</u>

In considering the effect of differant storage treatments at a particular date of desprouting on yield and number of ware, it may be seen from Table 106 that storage until January (d_1) without T.C.N.B. at high and medium temperature resulted in a significant reduction in the yield of ware compared with low temperature storage. With regard to number of ware, the difference between high and low temperature in favour of low temperature was significant (Table 107). In the case of T.C.N.B. treatment, seeds stored at high and medium temperature gave a significantly smaller yield and number of ware than those stored at low temperature (Table 106 and 107). In comparing T.C.N.B. and no T.C.N.B. treatment, at medium and high temperature untreated seeds gave a significantly greater yield and number, but at low temperature the difference between them either in yield or in number was not significant (Table 106 and 107).

(iv) <u>Seed Tubers Stored until 20th February before Sprouting in Light</u>

For seed tubers stored until February (d_2) without T.C.N.B., increase in storage temperature before sprouting in light caused a significant reduction in yield and number of ware. In the case of T.C.N.B. treatment, seeds held at medium temperature until February (d_2) produced a significantly smaller yield and number of ware than those stored at high temperature, while low temperature storage continued to give the highest yield and number of ware (Table 106 and 107). In considering T.C.N.B. and no T.C.N.B. treatment, seeds stored at high and low temperature did not show a significant difference between T.C.N.B. and no T.C.N.B. treatment either in yield or in number, whereas at medium temperature untreated seeds gave a significantly greater yield and number of ware than treated seeds (Table 106 and 107).

(v) Seed Tubers Planted Directly from Storage

Seeds planted directly from storage (d_3) without T.C.N.B. at high temperature produced a significantly smaller yield and number of ware than those stored at medium and low temperature, but the difference between medium and low temperature was not significant; however, seeds stored at low temperature gave a significantly greater number of ware than those stored at medium temperature (Table 106 and 107). In the case of T.C.N.B. treatment there was no significant difference in yield and number of ware between medium and high temperature, but both of these temperature treatments gave a significantly smaller yield and number of ware than seeds stored at low temperature (Table 106 and 107). Irrespective of temperature of storage, untreated seeds gave significantly greater yield and number of ware than those stored with T.C.N.B. (Table 106 and 107).

4. Yield (Tons/Acre) and Number (1000/Acre) of Seed ($2\frac{1}{4}$" - $1\frac{1}{4}$")

The analysis of variance of yield and number of seed has been presented respectively in Appendix 80 and 81.

The effects of variety, date of desprouting, storage treatment and the interactions between date of desprouting with seed size, variety with date of desprouting, variety with date of desprouting and seed size, treatment with variety, treatment with date of desprouting, treatment with seed size on yield and number of seed were significant. However, more detailed information on these effects may be obtained from the consideration of the interactions of treatment, variety and date of desprouting (T x V x D) and also from treatment, variety and seed size (T x V x S) which were also significant (Appendix 80 and 81).

(a) Effect of Treatment and Date of Desprouting on the Yield and Number of Seed in Arran Pilot and Majestic

As varieties responded significantly differently to treatment and date of desprouting, they are discussed separately to explain the interaction of the effect of storage treatment with date of desprouting on the yield and number of seed.

Arran Pilot

(i) The Main Effect of Storage Treatment (Average of Three Dates of Desprouting) in Arran Pilot

The main effect of storage treatment (average of three

TABLE 108

Effect of storage treatment and date of desprouting on the yield of seed (tons/acre) in Arran Pilot

Storage Temperature	Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65°–80°F)	6.840	4.068	3.636	4.848	7.182	7.164	0.504	4.950
Medium (50°–60°F)	10.368	6.966	2.466	6.600	9.306	5.778	2.430	5.838
Low (40°F)	12.258	13.968	13.248	13.158	13.698	13.402	12.402	13.110

S.E. of Treatment x Variety ± 0.335

S.E. of Treatment x Variety x Date of Desprouting ± 0.579

N.B. d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting.

TABLE 109

Effect of storage treatment and date of desprouting on the number of seed (1000/acre) in Arran Pilot

Storage Temperature	Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65°-80°F)	87.12	51.79	41.14	60.02	90.51	83.89	6.13	60.18
Medium (50°-60°F)	129.23	86.31	28.88	81.47	116.48	75.02	26.46	72.65
Low (40°F)	144.07	163.11	153.10	153.43	164.07	152.14	142.13	152.78

S.E. of Treatment x Variety ± 3.61

S.E. of Treatment x Variety x Date of Desprouting ± 6.24

N.B. d_1 = Desprouted on 4. 1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting.

TABLE 110

EFFECT OF DATE OF DESPROUTING ON THE YIELD OF SEED (TONS/ACRE) IN ARRAN PILOT AND MAJESTIC

Variety	Date of desprouting			Mean
	d_1	d_2	d_3	
Arran Pilot	9.942	8.529	5.781	8.084
Majestic	7.650	5.706	6.402	6.586

S.E. of Variety ± 0.160
S.E. of Variety x Date of desprouting ± 0.218.

TABLE 111

EFFECT OF DATE OF DESPROUTING ON THE NUMBER OF SEED (1000/ACRE) IN ARRAN PILOT AND MAJESTIC

Variety	Date of desprouting			Mean
	d_1	d_2	d_3	
Arran Pilot	121.91	102.04	66.31	96.75
Majestic	74.91	56.57	63.27	64.92

S.E. of Variety ± 1.87
S.E. of Variety x Date of desprouting ± 2.84

N.B. d_1 = desprouted on 4.1.61

d_2 = " " 20.2.61

d_3 = " at the time of planting.

dates of desprouting) indicated that the higher the temperature of storage, irrespective of T.C.N.B. treatment, the lower the yield of seed tubers in the subsequent crop. The reduction in yield of seed from medium temperature storage was very marked and there was a further significant reduction at high temperature. At any storage temperature there was no significant difference in yield and number of seed tubers between T.C.N.B. treatment and no T.C.N.B. treatment (Table 108 and 109).

(ii) The Effect of Date of Desprouting (Average of Storage Treatments) in Arran Pilot

The effect of date of desprouting (average of all treatments) showed that delay in time of desprouting caused a decrease in the yield and number of seed tubers (Table 110 and 111) which can be associated, however, with longer periods of storage at medium and high temperature regardless of T.C.N.B. treatment (Table 108 and 109).

(iii) Effect of Storage Treatments at Different Dates of Desprouting

Higher temperatures (medium and high) of storage until January (d_1), February (d_2) before sprouting in light or throughout (d_3) the storage period caused a significantly smaller yield and number of seed per acre than low temperature storage. The reduction was more marked the longer the period of storage. This effect of higher temperature was found to a greater or lesser extent in T.C.N.B. treated and untreated tubers (Table 108 and 109).

Tubers stored without T.C.N.B. at medium temperature until January (d_1) and February (d_2) before sprouting in light gave significantly greater yield and number of seed tubers than those stored at high temperature, but the difference in these two temperature treatments was not significant when tubers were stored throughout (d_3) [Table 108 and 109). In the case of T.C.N.B. treatment until January (d_1) or throughout the storage period, tubers stored at medium temperature produced significantly greater yield and number of seed tubers compared with those stored at high temperature (Table 108 and 109).

(iv) Seed Tubers Stored at Low Temperature before Sprouting or Planting

In considering the effect of time of sprouting, tubers stored at low temperature without T.C.N.B. until February (d_2) or throughout (d_3) produced greater amounts of seed (yield and number) than those sprouted during January (d_1) and the difference in favour of February (d_2) sprouting for greater yield of seed was significant (Table 108 and 109). This effect may be related to stem numbers, as indicated in Fig. 16 A, since the total number of tuber-producing stems (main stem + underground branches from main stem) in February sprouted (d_2) tubers was greater and thus produced a greater amount of seed than January (d_1) or unsprouted (d_3) tubers: the difference in stem number between January sprouted (d_1) and unsprouted tubers in favour of the former was not well marked.

In the case of T.C.N.B. treatment with low temperature storage, January (d_1) and February (d_2) sprouted tubers produced a greater amount of seed than unsprouted tubers and the difference in favour of January sprouting for greater yield and number of seed per acre was significant (Table 108 and 109). Fig. 16 B shows that tubers sprouted in January (d_1) and February (d_2) formed a greater number of tuber-producing stems per plant than unsprouted (d_3) tubers which may account for the larger numbers of seed from sprouted tubers (Table 108 and 109) with a decrease in the formation of ware (Table 102 and 103) compared with unsprouted tubers (d_3).

No significant effect from T.C.N.B. on yield of seed tubers, irrespective of time of sprouting, was found at low temperature (Table 108).

The main effect of variety (average of treatments and date of desprouting) indicated that Arran Pilot formed significantly greater amounts (yield and number) of seed than Majestic (Table 110 and 111) although exceptions to this main effect were evident with different storage treatments and times of desprouting and the two varieties showed different responses to treatments.

Majestic

(i) The Main Effect of Storage Treatment (Average of Three Dates of Desprouting) in Majestic

The main effect of storage treatment (average of dates of desprouting) showed that in Majestic in tubers stored without T.C.N.B. at different temperatures, an increase in temperature of storage caused a significant reduction in yield and number of seed tubers. Thus tubers stored at low temperature produced maximum yield (9.1 tons/acre) and number of seed per acre, intermediate at medium temperature (6.5 tons/acre) and lowest at high temperature (5.3 tons/acre). On the other hand, T.C.N.B. treated tubers stored at medium temperature gave a significantly smaller yield and number of seed tubers than those stored at high temperature, while low temperature storage continued to give the highest yield of seed (Table 112 and 113).

In Majestic, with the exception of tubers stored at medium temperature, T.C.N.B. treated tubers at low and high temperature (average of three dates of desprouting) produced a greater amount of seed tubers than those stored without T.C.N.B., but the difference in favour of T.C.N.B. treatment for high yield of seed was significant at low temperature (Table 112 and 113).

(ii) The Effect of Date of Desprouting (Average of Storage Treatment) in Majestic

Decrease in yield and number of seed per acre

TABLE 112

Effect of storage treatment and date of desprouting on the yield of seed (tons/acre) in Majestic

Storage Temperature	Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65^o-80^o)	7.380	4.780	3.888	5.352	9.918	5.778	3.024	6.240
Medium (50^o-60^oF)	8.928	6.102	4.752	6.594	2.718	0.846	1.584	1.716
Low (40^oF)	8.154	8.532	10.908	9.198	8.802	8.190	14.256	10.416

S.E. of Treatment x Variety ± 0.335

S.E. of Treatment x Variety x Date of Desprouting ± 0.579

N.B. d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting.

TABLE 113

Effect of storage treatment and date of desprouting on the number of seed (1000/acre) in Majestic

Storage Temperature	Without T.C.N.B.				With T.C.N.B.			
	d_1	d_2	d_3	Mean	d_1	d_2	d_3	Mean
High (65°-80°F)	73.73	46.14	40.82	53.56	98.09	61.14	33.23	64.16
Medium (50°-60°F)	84.70	59.53	47.75	63.99	27.26	8.07	14.20	16.51
Low (40°F)	79.54	83.57	105.19	89.43	86.15	80.99	138.42	101.86

S.E. of Treatment x Variety ± 3.61

S.E. of Treatment x Variety x Date of Desprouting ± 6.24

N.B. d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting.

associated with a delay in desprouting before sprouting in light (main effect of date of desprouting in Majestic) [Table 110 and 111] can again be attributed to longer periods of storage at high and medium temperature with or without T.C.N.B. (Table 112 and 113).

(iii) Effect of Storage Treatments and Different Dates of Desprouting

Storage at high (with or without T.C.N.B.) and medium temperature (without T.C.N.B.) for a short period until January (d_1), before sprouting, did not show any adverse effect on seed production and yielded more or less the same amount of seed tubers as tubers stored at low temperature (regardless of T.C.N.B.) until January (d_1) [Table 112 and 113]. At both later dates of desprouting (d_2 and d_3) medium and high temperature storage, irrespective of T.C.N.B. treatment, caused a significant reduction in yield and number of seed and this was especially marked with medium temperature with T.C.N.B. (Table 112 and 113).

(iv) Seed Tubers Stored at Low Temperature before Sprouting or Planting

With tubers stored at low temperature a delay in sprouting in light (d_2) or planting directly (d_3) caused an increase in yield and number of seed tubers (Table 112 and 113). Thus, irrespective of T.C.N.B. treatment, unsprouted tubers gave a significantly greater yield and number of seed tubers than those sprouted during January (d_1) and February (d_2), but the difference between January (d_1) and February (d_2) sprouting was not significant (Table 112 and 113). Majestic tubers stored with T.C.N.B. at low temperature throughout the storage period produced the maximum amount of seed (14.2 tons, i.e. 138.4 thousands of seed per acre), significantly greater than those stored without T.C.N.B. (Table 112 and 113). Large numbers and yield of seed from unsprouted tubers may be related to the greater number of main stems (Fig. 16 C and D) which reduced the yield of ware (Table 106 and 107) and thus increased the yield of seed tubers (Table 112 and 113).

(b) Effect of Treatment and Seed Size on Yield (Tons/Acre) and Number (1000/Acre) of Seed Tubers in Arran Pilot and Majestic (T x V x S)

The main effect of seed size (average for all storage treatments) showed that in both varieties large seed produced a significant increase in yield and number of seed tubers over small seed (Table 114 and 115), but this effect of seed size did not apply to all treatments and was reversed in the case of Majestic stored at medium temperature with T.C.N.B., and with Arran Pilot stored at high temperature with T.C.N.B. (Table 116 and 117).

In Arran Pilot large seed stored at low and medium temperatures, irrespective of T.C.N.B. treatment, gave a significantly greater amount of seed tubers than small

TABLE 114

EFFECT OF SEED SIZE ON THE YIELD OF SEED TUBERS (TONS PER ACRE)
IN ARRAN PILOT AND MAJESTIC

Variety	Large seed	Small seed
Arran pilot	8.568	7.600
Majestic	7.242	5.930

S.E. of Variety x seed size ± 0.177

TABLE 115

EFFECT OF SEED SIZE ON THE NUMBER OF SEED TUBERS (1000/ACRE)
IN ARRAN PILOT AND MAJESTIC

Variety	Large seed	Small seed
Arran pilot	102.64	90.87
Majestic	71.90	57.94

S. E. of Variety x seed size ± 2.31.

TABLE 116

Effect of treatment and seed size on the yield of seed tubers (tons/acre) in Arran Pilot and Majestic

Storage Temperature	Arran Pilot				Majestic			
	Without T.C.N.B.		With T.C.N.B.		Without T.C.N.B.		With T.C.N.B.	
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed
High (65^{o}-80^{o}F)	5.100	4.596	4.320	5.580	6.060	4.644	7.380	5.100
Medium (50^{o}-60^{o}F)	7.212	5.988	6.828	4.848	6.900	6.288	1.200	2.232
Low (40^{o}F)	14.196	12.120	13.752	12.468	10.452	7.944	11.460	9.372

S.E. of Treatment x Variety x Seed Size ± 0.473

TABLE 117

Effect of treatment and seed size on the number of seed tubers (1000/acre) in Arran Pilot and Majestic

Storage Temperature	Arran Pilot				Majestic			
	Without T.C.N.B.		With T.C.N.B.		Without T.C.N.B.		With T.C.N.B.	
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed
High (65°-80°F	63.78	56.25	50.66	69.69	61.84	45.28	75.07	53.24
Medium (50°-60°F	88.95	74.00	86.15	59.15	67.11	60.88	11.18	21.83
Low (40°F)	162.41	144.45	163.91	141.65	101.75	77.12	114.44	89.27

S.E. of Treatment x Variety x Seed Size ± 5.11

seed. In Majestic large tubers stored at low and high temperature, irrespective of T.C.N.B. treatment, produced a significantly greater amount of seed than small tubers (Table 116 and 117).

From the above results it seems that the advantage from large seed in the production of greater amount of seed size tubers was not evident after unfavourable storage conditions, such as high and medium temperature storage before sprouting.

E. DISCUSSION

EXPERIMENT 4

Weight Losses of Tubers before Sprouting or Planting

The loss in tuber weight due to both sprouting and other losses (transpiration and respiration) was greater in Arran Pilot (a vigorous sprouting variety) than in Majestic (a slow sprouting variety), but both varieties showed a similar response to storage treatment.

The loss in tuber weight due to sprout growth was related to the storage temperature and treatment with T.C.N.B. In the case of tubers stored without T.C.N.B., weight losses due to sprout growth during storage were least where the temperature of storage was 40°F. With higher storage temperature (50°-60°F) sprout growth increased but a further increase in temperature to 65°-80°F tended to give less sprouting. Barker (1937) showed that increase in the rate of sprout growth occurred by increasing the temperature of the storage from 41°F to 59°F, but above that the increase was less marked. Headford (1960 and 1962) also suggested the inhibiting effect of high temperature on the growth of sprouts. According to this author increase in temperature to 86°F caused a decrease in the growth rate of sprouts due to the death of the sprout apex. The growing points also died after some months storage at 68°F and 77°F and as a result the longest sprouts were finally produced at 59°F.

Owers (1960) and later Shotton (1961) observed that with tubers exposed to fluorescent strip lighting sprout length increased at planting time with increase in temperature from 45°F to 55°F or 65°F but further increase in temperature to 75°F resulted in a decrease in sprout length.

In the present experiment it was observed that losses due to respiration and transpiration increased directly with increase in storage temperature and, as these formed the major source of loss, total weight losses were minimum at 40°F, intermediate at 50°-60°F and maximum at 65°-80°F.

T.C.N.B. exerted little effect on total weight losses at low temperature where sprouting was at a minimum level, but at higher temperatures dust treatment reduced the amount of sprout loss and total losses which in this instance increased directly with increase in temperature.

The actual weight losses due to both sprouting and other losses (transpiration and respiration) was greater in large seed than in small seed,but the percentage weight losses of tubers of the two seed sizes were similar. Making particular reference to the amount of sprout development, Headford (1962) showed that the growth in dry weight of sprouts from tuber pieces was directly proportional to the size of the attached tuber piece.

Sprout Growth in Light

In tubers that were sprouted in light before planting the previous storage treatment was found to have a considerable influence on subsequent sprout growth. With a storage period of 8 weeks increase in temperature resulted in an increased subsequent sprout growth, irrespective of T.C.N.B. From a practical viewpoint, where the sprouting period is relatively long, storage at low temperature may thus have a beneficial after-effect in preventing the development of excessively long sprouts, while conversely previous storage at high temperature may aggravate problems relating to excessive sprout length. Greater growth of sprouts in light after previous storage at high and medium temperatures compared with that after storage at low temperature might be related to the effect of temperature on the physiological development of the tuber reserves, higher temperatures advancing physiological development and stimulating subsequent sprout growth. It was suggested by Madec and Perennec (1960a) that the growth and development of sprouts was governed by the physiological age of the tuber, this itself depending upon the actual age and also on the environmental conditions during storage, temperature being one of the factors involved.

Where tubers were held for a longer period of storage (4.11.60 to 20.2.61) without T.C.N.B., increase in the temperature of storage from $40^{o}F$ to 50^{o}-$60^{o}F$ resulted in greater growth of sprouts in light, but there was no further response from further increase in temperature to

65^{o}-80^{o}F. T.C.N.B. had no effect at low temperature, irrespective of variety, on subsequent sprout growth as had been shown by Brown and Reavill (1954). T.C.N.B. was also found to have no after-effect on sprout growth in the case of Arran Pilot tubers stored at medium temperature and Majestic tubers stored at high temperature. High temperature storage of Arran Pilot tubers over a prolonged period (4.11.60 - 20.2.61) with T.C.N.B. inhibited subsequent sprout growth, which was below that of tubers from low temperature storage, and in the case of medium temperature storage of Majestic it had a markedly adverse effect, many tubers failing to produce any sprouts. Brown and Reavill (1954) showed that seed tubers (var. Arran Pilot and Home Guard) stored at higher temperature for about four months gave abnormal sprout development (witches brooms) and sometimes a side sprout drilled its way into, or through, the tuber. This type of monstrosity was seen in the present experiment at the time of desprouting, a few times in Majestic and quite frequently in Arran Pilot.

Delay in sprouting in light caused a decrease in sprout length but sprout numbers tended to be greater. However, tubers stored with T.C.N.B. until February before sprouting in light at high temperature in the case of Arran Pilot or at medium temperature in the case of both varieties gave smaller numbers of sprouts than comparable tubers sprouted in January, indicating a possible adverse effect of these treatments on bud activity. With regard to low temperature storage, the present observation agrees with the finding of earlier authors (Bushnell 1929, Kawakami 1953, Toosey 1959 and Hiele 1961) that delay in time of sprouting following low temperature storage results in an increase in sprout number.

While the weight of sprouts at the end of the sprouting period in light tended to increase with the increase in previous temperature of storage, the total number of sprouts developed in both varieties was maximum at low temperature treatment. There was little difference in effect between high and medium temperature storage, but medium temperature in combination of T.C.N.B. in Majestic gave a smaller number of sprouts than high temperature treatment. Large numbers of sprouts per tuber stored previously at low temperature compared with high and medium temperature treatment was mostly due to larger numbers of sprouted eyes per tuber.

Numbers of sprouts formed per tuber at the time of planting were related to seed size and variety. Thus in both varieties large seed gave a greater number of sprouts than small seed which agrees with the findings of earlier workers (Appleman 1918, Aicher 1920, Bushnell 1929, Bates 1935, Toosey 1959). Arran Pilot (a vigorous sprouting variety) was found to give a greater number of sprouts than Majestic (a slow sprouting variety).

Growth and Plant Development in the Field

(A) Rate of Plant Emergence

The final number of plants that emerged was affected by the previous conditions of storage and incomplete stands were obtained from (a) tubers of Majestic stored at 50^{o}-$60^{o}F$ or 65^{o}-$80^{o}F$ with T.C.N.B. until January, (b) tubers of both varieties stored at 65^{o}-$80^{o}F$ irrespective of T.C.N.B., (c) at 50^{o}-$60^{o}F$ with T.C.N.B. until February, and (d) stored until planting time at 65^{o}-$80^{o}F$ and 50^{o}-$60^{o}F$ irrespective of T.C.N.B. treatment. The percentage failure in plant emergence was highest where tubers were planted direct for high and medium temperature storage. In both varieties reduction in sprout loss or total loss in tuber weight at 65^{o}-$80^{o}F$ or at 50^{o}-$60^{o}F$ by dusting T.C.N.B. did not show any favourable effect in plant emergence compared with that of tubers stored without T.C.N.B. and in fact T.C.N.B. at higher temperatures (50^{o}-$60^{o}F$ or 65^{o}-$80^{o}F$) in both varieties gave lower plant stands than comparable tubers stored without T.C.N.B. It seems that the combined effect of T.C.N.B. and higher temperature of storage adversely affected subsequent growth of foliage in the field.

Considering the plants that did emerge, many previous workers (Appleman 1918, Hanlan 1929, Hardenburgh 1928, 1935, Filimanov and Rustshkina 1934, McCubbin 1941, Eastman and Libby 1948, Toosey 1960) have reported earlier plant emergence from tubers sprouted before planting compared with unsprouted or desprouted tubers, as was found in the present experiment.

In the case of Arran Pilot, with the exception of high temperature (65^{o}-80^{o}F) storage where a shorter storage period (until January) before sprouting showed better plant emergence, there was no significant difference in the rate of plant emergence between tubers sprouted in January and February. These observations suggest that in Arran Pilot there was no advantage in early sprouting (January) with regard to early plant emergence except in the case of previous storage at high temperature (65^{o}-80^{o}F) which over a longer period of storage had an adverse effect on subsequent sprout growth. In the case of previous storage at low and medium temperature, tubers sprouted in February gave sprout lengths which exceeded the optimum of 15 mm. (Headford 1960 and 1962) and no benefit in early plant emergence was obtained from earlier (January) sprouting treatment.

In Majestic, with the exception of medium temperature storage without T.C.N.B., tubers stored until January before sprouting in light produced plants above ground earlier than those stored until February. It seems that in Majestic there is some advantage in early sprouting (January) which may be related to a larger number of longer sprouts (31 to 60 mm.), whereas longest sprout length from February sprouting range mostly from 11 to 30 mm.

Working with the variety King Edward (a main crop variety) having sprout lengths of 0.2, 2 and 5 cm., Headford (1962) found that the time of emergence was reduced with increase in sprout size.

Owers (1960) suggested that the slow sprouting varieties such as Majestic and King Edward needed a longer period of sprouting (7 to 8 weeks) for early plant emergence whereas Arran Pilot, which is noted for its rapidity of sprout growth, showed early emergence when the period of sprouting was short (5-6 weeks).

Large seed emerged earlier than small seed which confirms the findings of Werner (1919). However, this advantage from large seed was not evident after unfavourable storage conditions such as medium temperature with T.C.N.B. in Majestic where small seed emerged earlier than large seed.

(B) Tuber Yield

(i) Temperature Effect on Tuber Yield and Grade of Produce

(a) Total Yield. The temperature of storage of seed before sprouting or planting was found to have a considerable influence on the subsequent yield of tubers (in terms of dry weight) at different stages of plant growth and at final harvest. Thus seed of both varieties stored above 40°F (i.e. at 50°-60°F or 65°-80°F) before sprouting or planting showed earlier maturity with restricted foliage growth and tuber production and gave a significantly lower final tuber yield than that of seed stored at low temperature, irrespective of T.C.N.B. treatments. The extent of the unfavourable effect of higher storage temperature (50°-60°F or 65°-80°F) on tuber yield was aggravated with the delay in sprouting (giving longer period of exposure to higher temperature) or planting directly from storage. It was also observed during plant growth studies that with high and medium temperature treatments the mother tuber sometimes formed many small tubers underground with practically no growth of foliage, i.e. a 'little potato' (Davidson 1958b) and the incidence of 'little potato' was increased when the period of storage at high and medium temperature was prolonged. The adverse effect of higher storage temperatures (50°-60°F or 65°-80°F) on final yield was greater in Arran Pilot and in this variety seed tubers planted directly from cold storage gave significantly greater yields than those stored at higher temperatures even when the storage period was only until January and seeds were sprouted before planting. In the case of Majestic, the differences in total yield between seed tubers stored at high (65°-80°F) or medium temperature (50°-60°F) without T.C.N.B. until January and those stored throughout at low temperature were not significant. The differences in response between the two varieties associated with short periods of storage at high and medium temperature before sprouting may be related to their respective maturity classes. Thus in the case of an early variety such as Arran Pilot which naturally matures relatively quickly even a short period (until January) of exposure to higher temperature (50^{o}-60^{o}F or 65^{o}-80^{o}F) storage by shortening the growing period still further might have a proportionately greater effect on final yield than in a late maturity variety which has a longer growing period.

Making particular reference to the incidence of 'little potato', Van Schreven (1956) reported that the loss of reserve food material during three months storage at 68^{o}F prior to planting, produced 33% of the condition 'little potato' when the controlled growing conditions after planting were cold. Using the same storage and growing condition but desprouting the tubers before planting, the author found 100% 'little potato'. Storage at 50^{o}F, coupled with desprouting before planting in good growing conditions, also produced 33% 'little potato'. Davidson (1958b) states "A feature of warm storage is the incidence of 'little potato', a physiological condition where the life cycle is contracted as evidenced by the production of young tubers on the sprouts of the old set". The author (Davidson 1958b) considered that three factors were involved in the incidence of 'little potato', viz. (1) warm storage, (2) proliferated sprouting due to injury of any form to the apical sprout or sprouts, and (3) a cool period after planting.

With respect to developmental changes in the tuber Madec and Perennec (1960a) have found that potato sprouts may pass through all stages of development such as tuberisation, flowering and maturity while only depending on the mother tuber reserves for their nutrition. Making particular reference to the tuberisation of sprouts the authors considered that the rate of development was strongly influenced by environment, being hastened by humidity, heat and darkness at least after the beginning of sprouting, while in the same environment sprouts of the oldest tubers were the first to develop tubers. The factor inducing tuberisation was associated with chemical changes in the tuber reserves and its formation was stated to be hastened by high temperature and delayed but not inhibited by low temperature. Three stages in the physiological evolution of the tuber reserves were distinguished: a phase of non-growth of sprouts extending from time of tuber initiation on the mother plant to the end of the rest period; a phase where sprout growth was possible; a phase of non-growth of sprouts and of the growth of the daughter tuber. The direct formation of tubers from seed after periods of exposure to high temperature might be related to the seed reaching a stage of development when vegetative (sprout) growth is no longer possible.

(b) Stem Number, Tuber Number and Grade of Produce

While storage at higher temperature (50°-60°F or 65°-80°F) before sprouting in light gave a larger number of sprouts between 31-60 mm. or over 60 mm. than low temperature storage, the numbers of aerial stems (main stems + underground branches) formed per plant or per acre decreased with increasing temperature of storage. Thus in both varieties the maximum number of aerial stems derived from seeds stored previously at low temperature, intermediate from medium (50°-60°F) and lowest from high temperature (65°-80°F). A similar trend was observed when seeds were stored with T.C.N.B., but due to the adverse effect of medium temperature in combination with T.C.N.B. on sprout formation in Majestic a smaller number of aerial stems was formed at medium temperature than at high temperature in this variety. It would appear from the above result that previous storage at medium or high temperature has an adverse effect on subsequent terminal or axillary bud activity. This adverse effect was more marked when the period of exposure was prolonged. As a result of the smaller number of stems associated with increased temperature of storage, the number of tubers formed during plant development and also numbers per acre at final harvest decreased with the increase in temperature of storage.

With regard to grade of the produce, it was observed that Arran Pilot seed stored throughout the storage period at high (65^{o}-80^{o}F) and medium temperature (50^{o}-60^{o}F) gave less ware than seed held until planting time at low temperature, but the temperature of previous storage had no significant effect on yield of ware when seed tubers were sprouted in January or February. The yield of seed-size tubers was, however, reduced significantly with increase in the temperature of storage above 40^{o}F, irrespective of whether tubers had been sprouted or planted direct from storage. This effect on yield of seed tubers might be related to the reduced numbers of stems developing after higher temperature (50^{o}-60^{o}F or 65^{o}-80^{o}F) storage, the fewer tubers that were formed attaining ware size due to less competition. Yield of ware was only adversely affected where the vigour of subsequent plant growth was diminished with prolonged storage at higher temperature. The yield of marketable-sized tubers (ware + seed) was reduced with increase in storage temperature before sprouting or planting.

In Majestic, where yield (averaged for storage treatment) of ware was significantly greater and yield of seed-size tubers significantly smaller than in Arran Pilot, storage at high or medium temperature irrespective of T.C.N.B. before sprouting or planting caused a significant reduction of ware below that of low temperature storage. In the case of yield of seed-size tubers, storage at high (irrespective of T.C.N.B.) and medium temperature (without T.C.N.B.) until January before sprouting in light did not result in a significant reduction compared with low temperature storage. However, prolonging the period of storage at higher temperature (50°-60°F or 65°-80°F) until February or throughout resulted in a significant reduction of seed-size tuber. The yield of marketable-sized tubers (ware + seed) was again reduced with higher temperature of storage.

It seems that, irrespective of variety, storage at 50°-60°F or 65°-80°F before sprouting or planting resulted in early maturity with restricted growth of foliage and tuber production during the different stages of plant development and subsequently caused a significant reduction in final yield and yield of marketable-sized tuber (ware + seed).

(ii) Effect of Time of Sprouting from Low Temperature Storage on Tuber Yield and Grade of Produce

(a) Total Yield. In the case of low temperature storage, the present observations are in agreement with the findings of earlier workers (Appleman 1918, Hanlan 1929, Hardenburgh 1928, 1935, Jehle and Heuberger 1934, Filimanov and Rustshkina 1934, Eastman and Libby 1948) that sprouting before planting hastens early plant emergence followed by an increased rate of production of foliage and tubers during the early stages of growth. With regard to final yield there was, however, no advantage from sprouting in Arran Pilot, whereas there was a tendency for sprouted Majestic seed to give higher final yields than unsprouted seed although significant results were only obtained in the case of seeds sprouted in January from T.C.N.B. and those stored throughout at low temperature with or without T.C.N.B.

Several workers have reported beneficial effects of sprouting on final yield (Appleman 1918, Hanlan 1929, Hardenburgh 1928, 1935, Filimanov and Rustshkina 1934, Eastman and Libby 1948), but McCubbin (1941) considered that the final yield from sprouted and dormant seed would depend primarily on the time of planting, the length of the growing season and climatic conditions. With early planting or a growing season sufficiently long to permit plants of the two seed treatments (sprouted and dormant) to attain complete maturity under equally favourable climatic conditions, yield would no doubt be equal. With late planting, or a short growing season in which plants of two seed treatments were killed by frost or blight before maturity, yield would probably be greater from sprouted seed compared with dormant seed. Toosey (1962) also indicated that where growth of foliage was not cut down by late blight, there was no significant difference in final yield between sprouted and unsprouted seed. Whitehead etal (1953) considered that in late varieties frost may cause the foliage to die down before the plant reaches natural maturity and increased yields due to the use of sprouted seed tubers have been especially evident in late varieties and in late districts.

In present studies all plants reached natural maturity with no evidence of premature leaf senescence due to environmental or disease factors in the field. The difference in response between the two varieties considered in the present study may be related to their difference in maturity characteristics. With Arran Pilot, an early maturing variety, maximum foliage growth from sprouted tubers was in general attained in July, whereas unsprouted tubers gave maximum foliage growth in August when the amount exceeded that of sprouted tubers. Although no data is available for seasonal differences in net assimilation rate of potato plants in Scotland, evidence from England (Watson 1947) would suggest that maximum efficiency of assimilation (E) occurs in the period July to August and thus the extended period of leaf development at this time from unsprouted tubers would make an important contribution to crop yield which might be expected to compensate for later emergence and foliage development relative to that from sprouted tubers. On the other hand, in Majestic maximum foliage growth in both sprouted and unsprouted tubers was attained in August and slightly higher amounts of foliage from unsprouted seed compared with that of sprouted seed were not generally evident until September. Thus any advantage from delayed leaf senescence or later maturity from unsprouted seed did not occur in Majestic until late in the season when efficiency of assimilation (E) may be presumed to have fallen, and did not reach a level to compensate for the earlier emergence and growth development during the early part of the season compared with that of sprouted tubers, which as a result tended to give a higher final yield. Grikhestik (1941) reported that sprouting seed potatoes of early, medium and late varieties for 5-6 weeks in light at 53.6°F to 64.4°F before planting resulted in early bulking and higher yield than from unsprouted seed tubers and this effect was marked in the case of the late varieties.

There was also evidence that Majestic responded more favourably to the earlier sprouting in January compared with sprouting in February. Owers (1960) suggested that the slow sprouting varieties such as Majestic and King Edward needed a longer period of sprouting than Arran Pilot which is noted for its rapidity of sprout growth. According to the author, in the case of Arran Pilot shortening the period of sprouting to 5-6 weeks hastened early plant emergence followed by early tuberisation and greater yield as compared to those held for a long period (7-8 weeks), whereas Majestic and King Edward responded more favourably when seed tubers were sprouted for the longer period (7-8 weeks). In the present study it may be noted, however, that no difference in yield was found for 16 and 9 weeks sprouting in Arran Pilot.

In comparing T.C.N.B. and no T.C.N.B. treatments at low temperature storage it was observed that, irrespective of variety and period of storage, there was no significant difference in final yield between the two treatments. Even untreated tubers sprouted during January or February did not give a significantly greater final yield than those stored throughout with T.C.N.B. These results are not in close agreement with those of Brown and Reavill (1954) and Downic (1950). Brown and Reavill (1954) suggested that a period of 7 weeks of airing is required for T.C.N.B. treated tubers to equal in yielding capacity the chitted controls (stored without T.C.N.B. and sprouted in light at the same time when T.C.N.B. treated tuber was aired). Downic (1950) working with Snowflake variety found that T.C.N.B. treated tubers sprouted for one or two months before planting gave a smaller yield than untreated tubers.

(b) Stem Number, Tuber Number and Grade of Produce

In considering all tubers stored at low temperature before sprouting or planting, it was noted that in both varieties, irrespective of T.C.N.B. treatment, delay in sprouting in light resulted in an increase in sprout numbers, followed by a greater number of main stems per hill. Hardenburgh (1935) and later Toosey (1962) showed that delay in sprouting caused an increase in sprout numbers followed by increased numbers of main stems.

When comparing main stem numbers produced from sprouted (January and February sprouting) and unsprouted seed (stored throughout at low temperature) it was observed in the present experiment that in both varieties (irrespective of T.C.N.B. treatment) unsprouted seeds gave a greater number of main stems than those sprouted during January or February. These results are in agreement with those of Hartman (1934) who showed that seeds stored at 50°F produced a smaller number of main stems per hill than unsprouted seed (stored throughout at 32°F, 35°F and 40°F). Hardenburgh (1935) also indicated that sprouting before planting (2-6 weeks at 50°F) resulted in a significantly smaller number of stems compared with unsprouted seed. However, the present observation does not agree with the findings of Bushnell (1929) and McCubbin (1941) who considered that sprouted tubers produced a greater number of main stems than unsprouted seed.

In comparing the total number of tubers and the yield of ware and seed-size tuber from sprouted and unsprouted seed it was observed that the two varieties (Arran Pilot and Majestic) responded differently.

In Arran Pilot, unsprouted tubers, in spite of having a larger number of main stems, did not give a greater number of tubers or tubers of seed size than January and February sprouted seed. Conversely sprouted seed, in spite of producing a smaller number of main stems, did not give a greater yield of ware than unsprouted seed.

During the course of the present study it was shown that, irrespective of T.C.N.B. treatment, while sprouted seed gave rise to a smaller number of main stems they formed a larger number of underground branches from main stems which were able to produce tubers, and as a result the total number of tuber producing stems tended to be greater from sprouted seed than from seed stored throughout at low temperature. It seems from the present observation that in Arran Pilot underground branches from the main stem played an important part in tuber production and compensated for the smaller number of main stems developing from sprouted seed. In this connection it may be further stated that a larger number of nodes would result from sprouts developed in light from sprouted seed, giving rise to a larger number of stolons and tubers: in unsprouted seed the formation of underground nodes on the stems would be restricted due to etiolation in growth in soil. Thus Hardenburgh (1935) reported that sprouted seed, in spite of having a small number of main stems, gave rise to a larger number and weight of stolons and also a larger number of tubers per plant than unsprouted seed.

In comparing time of sprouting from low temperature storage in Arran Pilot, in the case of no T.C.N.B. treatment, February (d_2) sprouted seed tended to give a greater number of tubers with a significantly greater yield of seed-size tubers than that sprouted in January (d_1). This may be related to a greater number of tuber producing stems (main stems + underground branches from main stem) in the later sprouted seed, but time of sprouting had no significant effect on the yield of ware. In the case of T.C.N.B. treatment, time of sprouting had no significant effect on yield of ware and seed-size tuber in Arran Pilot, although it is difficult to explain why January (d_1) sprouted seed appeared to give a greater number of tubers per acre and also aerial stems per acre than that sprouted in February (d_2).

In Majestic, the development of underground branches from main stem was not so prevalent as in Arran Pilot. Thus unsprouted seed, having a larger number of main stems, gave a significantly greater number of tubers per acre (and also seed-size tubers) than that sprouted during January and February, while January and February sprouted seed, having a smaller number of main stems, gave a significantly greater yield of ware than unsprouted seed. These results are in agreement with those Hartman (1934) and Hardenburgh (1935) who indicated that sprouted seed gave a greater yield of large size tuber than unsprouted seed. It may be noted, however, that Toosey (1962) working with King Edward showed that, while early sprouted seed (December) formed a greater number of tubers and also a greater amount of ware than unsprouted seed, late sprouted seed (February) gave rise to a greater number of tubers and a smaller amount of ware than unsprouted seed.

In considering the time of sprouting from low temperature storage it was found that in Majestic, although January sprouting tended to give a smaller number of main stems than February sprouting, the difference in numbers between the two seed treatments was not marked and the differences in total number of tubers per acre and in yield of ware and seed-size tubers were not significant.

Hardenburgh (1935) reported that in Green Mountain and White Rural variety the number of stems as well as the number of tubers per hill decreased as the period of sprouting was increased from two to six weeks. Toosey (1962) also reported that in King Edward delay in sprouting caused an increase in main stem numbers followed by an increased number of tubers per acre. Yield of large size tuber was inversely proportional to stem number, whilst yield of small sized tubers varied directly with main stem number. The divergence from the findings of earlier workers with respect to total number of tubers, yield of ware and seed associated with the time of sprouting may be related to possible varietal differences in the number of stems formed in sprouted seed. Toosey (1960) considered that varieties differ greatly in the number of sprouts that become active and in the number of plants and tubers that they produce. This author further commented that at one extreme, Majestic produces relatively few plants and tubers from multiple sprouted seed and at the other extreme Stormont 480 produces an excessive number of plants and tubers per hill from multiple sprouted seed.

In both Arran Pilot and Majestic treatment of tubers with T.C.N.B. at low temperature until January and February before sprouting in light did not have any significant effect on the yield of ware and seed compared with those stored without T.C.N.B. When treatment with T.C.N.B. at low temperature was prolonged until planting time only Majestic gave a significantly greater yield of seed and smaller yield of ware than comparable tubers stored without T.C.N.B. In fact in Majestic maximum yield of seed was obtained when tubers were stored throughout at low temperature with T.C.N.B., which may be related to the maximum number of main stems per hill. Brown and Reavill (1954) had shown that in Home Guard T.C.N.B. treatment caused the formation of a greater number of stems and reduced the ware/seed ratio compared with that of sprouted seed (previously stored without T.C.N.B.) and control desprouted (stored throughout in clamp without T.C.N.B.), whereas in Arran Pilot the difference in ware/seed ratio between T.C.N.B. and no T.C.N.B. treatments was not significant.

(iii) Effect of Size of Seed on Tuber Yield and Grade of Produce

(a) Total Yield. The main effect of seed size (averaged for all storage treatments) in both varieties was that large seed produced a significant increase in yield over small seed and this result agrees with that of earlier investigators (Appleman 1918, Aicher 1920, Salaman 1921, 1922 and 1923, Filimanov and Rustshkina 1934, Chuck etal 1945, Hiele and Vervelde 1954) who reported that the rate of growth of the potato plant and the yield of tubers increased with the weight of the seed tuber. The effect, however, was not consistent for all treatments in the present investigation, being absent or reversed where tubers had been stored at higher temperatures and subsequent plant vigour was adversely affected. This would suggest that increased vigour from large seed may not occur following adverse storage conditions.

(b) Stem Number, Tuber Number and Grade of Produce

The main effect of seed size (averaged for all storage treatments) showed that in both varieties large seed produced a significantly greater number of tubers, and also yielded greater amounts of seed tubers than small seed. Seed size had no significant effect on ware yield. Greater numbers of tubers per acre and also a greater yield of seed-size tubers with increase in seed size may be related to the greater number of stems per plant (and also per acre) developed. It has been shown by earlier workers (Aicher 1920, Bates 1935, Chucka etal 1945, Toosey 1960) that the larger the seed size the greater the number of stems per hill. The number of tubers produced was directly related to the number of stems per hill whereas the size of the produce tended to be reduced with increase in stem number or the size of the tuber planted [Werner (1919), Aicher (1920), Clark (1921), Salaman (1921, 1922 and 1923), Bates (1935) Toosey (1960)]. Bates (1935) considered that the size of seed influenced yield and grade of produce in that it controlled the number of true plants in the hill and thereby controlled intensity of competition.

In the present experiment it was found that the advantage from large seed in the production of greater amounts of seed-size tubers was not evident after unfavourable storage conditions such as high (65^{o}-80^{o}F) and medium temperature storage before sprouting or planting.

F. CONCLUSIONS

EXPERIMENT 4

In Experiment 4 studies were carried out on the effect of storage temperatures of seed tubers of two sizes (small seed = 80-100 gms. and large seed = 120-140 gms.) and treatment with T.C.N.B. on weight losses in storage, subsequent sprout growth after desprouting, plant growth and development and final crop yield in Arran Pilot and Majestic.

1. In the case of tubers stored without T.C.N.B. at temperatures of $40^{o}F$, 50^{o}-$60^{o}F$ and 65^{o}-$80^{o}F$, weight losses in tubers due to sprout growth during storage were least at $40^{o}F$. With a higher storage temperature (50^{o}-$60^{o}F$) sprout growth was increased but a further increase in temperature to 65^{o}-$80^{o}F$ tended to give less sprouting. In the case of T.C.N.B. treatment losses in tuber weight due to sprout growth increased directly with the increase in storage temperature.

2. Losses in tuber weight due to transpiration and respiration increased directly with the increase in storage temperature and as these formed the major source of loss, the total weight losses were minimum at $40^{o}F$, intermediate at 50^{o}-$60^{o}F$ and maximum at 65^{o}-$80^{o}F$.

3. T.C.N.B. exerted little effect on total weight losses at low temperature where sprouting was at a minimum level

but at higher storage temperatures (50°-60°F or 65°-80°F) dust treatment reduced the amount of sprout loss and total weight losses.

4. The actual weight losses due to both sprouting and other losses (transpiration and respiration) varied directly with seed size but relative weight loss expressed on percentage basis was similar from large and small seed.

5. Previous temperature of storage was found to influence the subsequent growth of sprouts in light. With storage periods from November to January, increase in temperature from 40°F to 50°-60°F or from 50°-60°F to 65°-80°F stimulated subsequent sprout growth but over a longer period (November to February) high temperature storage (65°-80°F) did not give any further response over medium temperature (50°-60°F) and in some cases showed an after-effect in decreasing growth.

6. In Majestic T.C.N.B. at 50°-60°F adversely affected subsequent sprout growth in light and the majority of seed tubers failed to sprout in storage.

7. Treatment of T.C.N.B. at 65°-80°F in the case of Arran Pilot and at 50°-60°F in the case of Majestic had an adverse after-effect on sprout growth, but in all other cases (i.e. storage of Arran Pilot at low or medium temperature or storage of Majestic at low or high temperature) growth of sprouts in treated and untreated

tubers was similar.

8. Tubers stored at low temperature tended to give a larger number of sprouts than those stored at higher temperature (50^{o}-60^{o}F or 65^{o}-80^{o}F).

9. Large seed formed a larger number of sprouts and also showed a greater sprout growth (in weight) in light than small seed.

10. In Arran Pilot there was no advantage in early sprouting (January) with regard to early plant emergence except in the case of previous storage at high temperature (65^{o}-80^{o}F) where a shorter storage period (until January) showed better plant emergence than a longer period (until January) of storage. In Majestic there is some advantage in early sprouting (January) for early plant emergence.

11. Seed of both varieties which was stored at 50^{o}-60^{o}F before sprouting or planting formed a smaller number of stems and showed earlier maturity with restricted foliage growth and tuber production during different stages of plant development and also gave a significantly lower final yield and yield of marketable size tuber (ware + seed) than seed tubers stored at low temperature, irrespective of T.C.N.B. treatment. The unfavourable effect of higher temperature (50^{o}-60^{o}F or 65^{o}-80^{o}F) storage as evidenced by restricted plant development and also the incidence of 'little tuber'

was more marked when the period of exposure to higher temperature was prolonged.

12. In both varieties reduction in sprout loss or total loss in tuber weight at 50°-60°F or at 65°-80°F by dusting with T.C.N.B. did not show any favourable effect on subsequent plant development and in fact T.C.N.B. at higher temperatures (50°-60°F or 65°-80°F) in both varieties gave a smaller final plant stand than comparable tubers stored without T.C.N.B.

13. In the case of low temperature storage sprouting before planting hastened early plant emergence followed by an increased rate of production of foliage and tubers during the early stages of growth, but there appeared to be no advantage in final yield from sprouting in Arran Pilot. There was a tendency for sprouted Majestic seed to give higher final yields than unsprouted seed. There was also evidence that Majestic responded more favourably to the earlier sprouting in January compared with sprouting in February with regard to greater tuber yield at different stages of plant development and also yield at maturity.

With regard to grade of the produce, in Arran Pilot there was no significant difference in yield of ware (over $2\frac{1}{4}$" diameter) and seed ($1\frac{1}{4}$" to $2\frac{1}{4}$" diameter) between sprouted (January and February) and unsprouted seed (stored throughout at low temperature) irrespective of T.C.N.B. treatment. In fact in Arran Pilot underground branches from main stems able to produce tubers played an important part in tuber production and while sprouted seed formed a smaller number of main stems it produced a larger number of underground branches from the main stems, and as a result the total number of tuber-producing stems tended to be greater in sprouted seed than unsprouted seed.

In Majestic the development of underground branches from the main stem able to produce tubers was not found to such a great extent as in Arran Pilot and the grade of produce was largely determined by the number of main stems. Thus, irrespective of T.C.N.B. treatment, unsprouted seed tubers (stored throughout at low temperature) having a larger number of main stems, gave a significantly greater number of tubers and also yield of seed size tuber than sprouted seed (January and February), while sprouted seed having a smaller number of main stems produced a significantly greater yield of ware than unsprouted seed.

In both varieties treatment of seed with T.C.N.B. at low temperature until January, February or throughout did not have any significant effect on the total yield compared with those stored without T.C.N.B. With regard to grade of produce, irrespective of variety there was no significant difference in yield of ware and seed size tuber between T.C.N.B. and no T.C.N.B. treatment in the case of January and February sprouting. When the period of storage with T.C.N.B. at low temperature was prolonged until planting time only in Majestic, did a significantly greater yield of seed size tuber with a smaller yield of ware result.

14. The main effect of seed size (averaged for all storage treatments) showed that in both varieties large seed gave a significantly greater number of tubers and yield of seed size tubers than small seed. However, this size effect was not consistent for all treatments, being absent or reversed where tubers had been stored at higher temperature (50°-60°F or 65°-80°F).

Experiment 5. Effect of length of storage at high temperatures on weight losses in storage and subsequent plant development of seed potatoes.

A. Materials and Methods

Tubers weighing from 90-100 gms. were selected from a seed stock of Arran Pilot (Scottish Grade A) and made up into 14 lots, each of 25 tubers, which were weighed and placed into lidded tin boxes (10" x 9.5" x 4.8"). The various boxes numbered 1 to 14 received different storage treatments, as shown in Table 118, starting on 10th November, 1960.

The temperature ranges for medium (50°-60°F) and high (65°-80°F) temperature storage are summarised in Appendix 38. At each time of transfer to a different temperature the tubers in a box were weighed and any sprouts which had formed were removed and their fresh weight taken. Thus tubers of boxes 1 to 6 (Table 118) were weighed and desprouted where applicable on 8th January and on 6th March. A similar procedure was adopted for boxes 1 and 2 and 7 to 10 (Table 118). On 25th April, i.e. five days before planting, the tubers of all boxes were weighed and any sprouts present were removed and also weighed. In Appendix 88 the initial weight of tubers in each box and the weights of tubers and sprouts at the two times of transfer and at planting time are given.

Field Experiment. To study the effect of different

TABLE 118

Summary of Treatments of Experiment 5

1. Stored 8 weeks at $40^{\circ}F$ (10th Nov. to 8th Jan.), 8 weeks at $50^{\circ}-60^{\circ}F$ (8th Jan. to 6th March), 7 weeks at $40^{\circ}F$ (6th March to 25th April).

2. Stored 8 weeks at $40^{\circ}F$ (10th Nov. to 8th Jan.), 8 weeks at $65^{\circ}-80^{\circ}F$ (8th Jan. to 6th March), 7 weeks at $40^{\circ}F$ (6th March to 25th April).

3. Stored 8 weeks at $40^{\circ}F$ (10th Nov. to 8th Jan.), 15 weeks at $50^{\circ}-60^{\circ}F$ (8th Jan to 25th April).

4. Stored 8 weeks at $40^{\circ}F$ (10th Nov. to 8th Jan.), 15 weeks at $65^{\circ}-80^{\circ}F$ (8th Jan to 25th April).

5. Stored 8 weeks at $50^{\circ}-60^{\circ}F$ (10th Nov. to 8th Jan.), 15 weeks at $40^{\circ}F$ (8th Jan to 25th April).

6. Stored 8 weeks at $65^{\circ}-80^{\circ}F$ (10th Nov. to 8th Jan.), 15 weeks at $40^{\circ}F$ (8th Jan to 25th April).

7. Stored 16 weeks at $40^{\circ}F$ (10th Nov. to 6th March), 7 weeks at $50^{\circ}-60^{\circ}F$ (6th March to 25th April).

8. Stored 16 weeks at $40^{\circ}F$ (10th Nov. to 6th March), 7 weeks at $65^{\circ}-80^{\circ}F$ (6th March to 25th April).

9. Stored 16 weeks at $50^{\circ}-60^{\circ}F$ (10th Nov. to 6th March), 7 weeks at $40^{\circ}F$ (6th March to 25th April).

10. Stored 16 weeks at $65^{\circ}-80^{\circ}F$ (10th Nov. to 6th March), 7 weeks at $40^{\circ}F$ (6th March to 25th April).

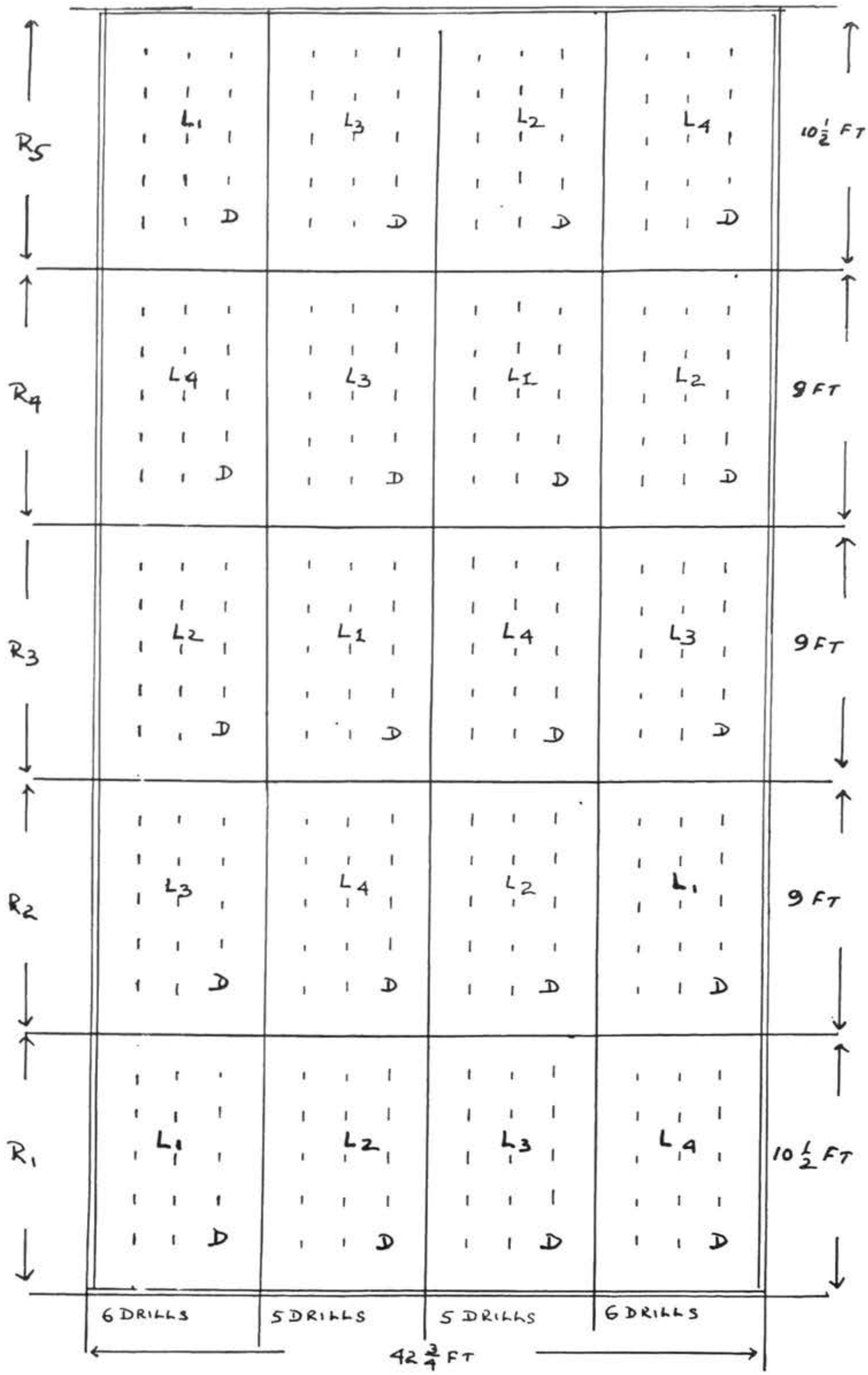
11. Stored throughout (23 weeks) at $50^{\circ}-60^{\circ}F$ (10th Nov. to 25th April).

12. Stored throughout (23 weeks) at $65^{\circ}-80^{\circ}F$ (10th Nov. to 25th April).

13. Stored throughout (23 weeks) at $40^{\circ}F$ (10th Nov. to 25th April).

14. Stored throughout (23 weeks) at $40^{\circ}F$ (10th Nov. to 25th April).

Fig. 17 LAY OUT OF THE EXPERIMENT 5



L_1 - 1st SAMPLING ON 4.7.61
L_2 - 2nd " " 25.7.61
L_3 - 3rd. " " 12.8.61
L_4 - 4th " " 14.9.61

D - DISCARD

storage treatments on subsequent plant development the tubers were planted out in an experimental plot to contain the following combination of factors.

A. Date of Lifting

1. First lifting on 4th July (64 days after planting)
2. Second lifting on 25th July (85 days after planting)
3. Third lifting on 12th August (103 days after planting)
4. Fourth lifting on 14th September (126 days after planting).

B. Treatment - 14 treatments as shown in Table 118.

Layout of Experiment (Fig. 17)

The experiment was of a split plot design in a randomised block system with five replications. Each replication was then divided into four main plots for the four dates of lifting which were randomised in each replication and the 14 treatments were randomised in each main plot.

In each main plot one tuber from each treatment was planted. So at the time of sampling, each treatment was represented by five plants, i.e. one plant from each replication.

The main plots were separated by single discard drills and guard tubers separated each replication. There were two guard rows on each side of the experimental plot and double guard tubers at each end of the plot. The area covered 48 ft. x 42¾ ft., i.e. 0.046 acre.

Planting. The tubers were planted on 1st May in 27" drills with 18" spacing between tubers.

Field Observation. Counts of plant emergence were made twice per week from 9th May until 8th June when the drills were finally ridged up.

For the purpose of blight control a spray of Perenox was applied on 24th June and again on 22nd August and throughout the growing period no blight was observed.

Plant Growth Studies

At each date of lifting the plants were brought into the laboratory, washed free of soil and the following observations were carried out: (1) the number and size (diameter in cm.) of tubers of each plant, (2) the dry weight of foliage of the five plants of each treatment, and (3) the dry weight of tubers of each plant separately. The dry weight was determined after drying for 24 hours at 95°-100°C.

Statistical Analysis and Method of the Presentation of Data

The data of the experiment related to rate of plant emergence, dry weight of tubers, were subjected to the "Analysis of Variance" appropriate to the designs. For the rate of emergence there was one estimate of error applicable to the effect of treatment. With regard to the dry weight of tubers, there were two estimates of error applicable to (a) effect of date of lifting, (b) effect of treatment and interaction of treatment with date of lifting.

The methods of statistical analysis were based on those of Yates (1937) and Paterson (1939).

The other information is recorded in the form of two way tables on the basis of the statistical analysis with the appropriate standard error. The difference is considered significant whenever the difference is greater than $\sqrt{2}$ x S.E. x t (Fisher and Yates 1949).

The progressive data on dry weight of foliage were presented as the mean of five plants.

RESULTS

B. Studies During Storage Period

1. Weight Losses in Storage

The weight losses of tubers due to sprout growth and other losses (transpiration and respiration) during storage at high (65°-80°F), medium (50°-60°F) or low (40°F) temperature related to the various storage treatments are given in Appendix 89, the losses being expressed as a percentage of the tuber weight at the beginning of heat treatment.

The effects of storage treatment on weight loss in storage may be considered under the following headings:

(i) Weight losses during varying periods of heat treatment applied at different times.

(ii) Weight losses during the total storage period.

(i) Weight Losses During Varying Periods of Heat Treatment Applied at Different Times

(a) Heat Treatment at Medium Temperature (50°-60°F) for 8 or 7 Weeks Period

The loss in weight of tubers due to sprouting was greatest (11.3%) during the period the heat treatment was applied during the last 7 weeks of storage, intermediate (8.1%) for 8 weeks at the middle and lowest (2.79%) for 8 weeks at the beginning of the storage period. Thus the amount of sprout production increased with increase in age

TABLE 119

Loss in wt. (%) of tubers due to sprouting, transpiration and respiration under different heat treatments (7-8 weeks)

Storage Treatment	50°-60°F			65°-80°F		
	Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt (%)	Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt (%)
First 8 weeks heat treatment and then 15 weeks at 40°F	2.79	1.72	4.51	2.10	2.49	4.59
First 8 weeks at 40°F and then 8 weeks heat treatment and then 7 weeks at 40°F	8.10	1.01	9.11	4.23	1.68	5.91
First 16 weeks at 40°F and then 7 weeks heat treatment	11.30	1.17	12.47	4.11	1.59	5.70

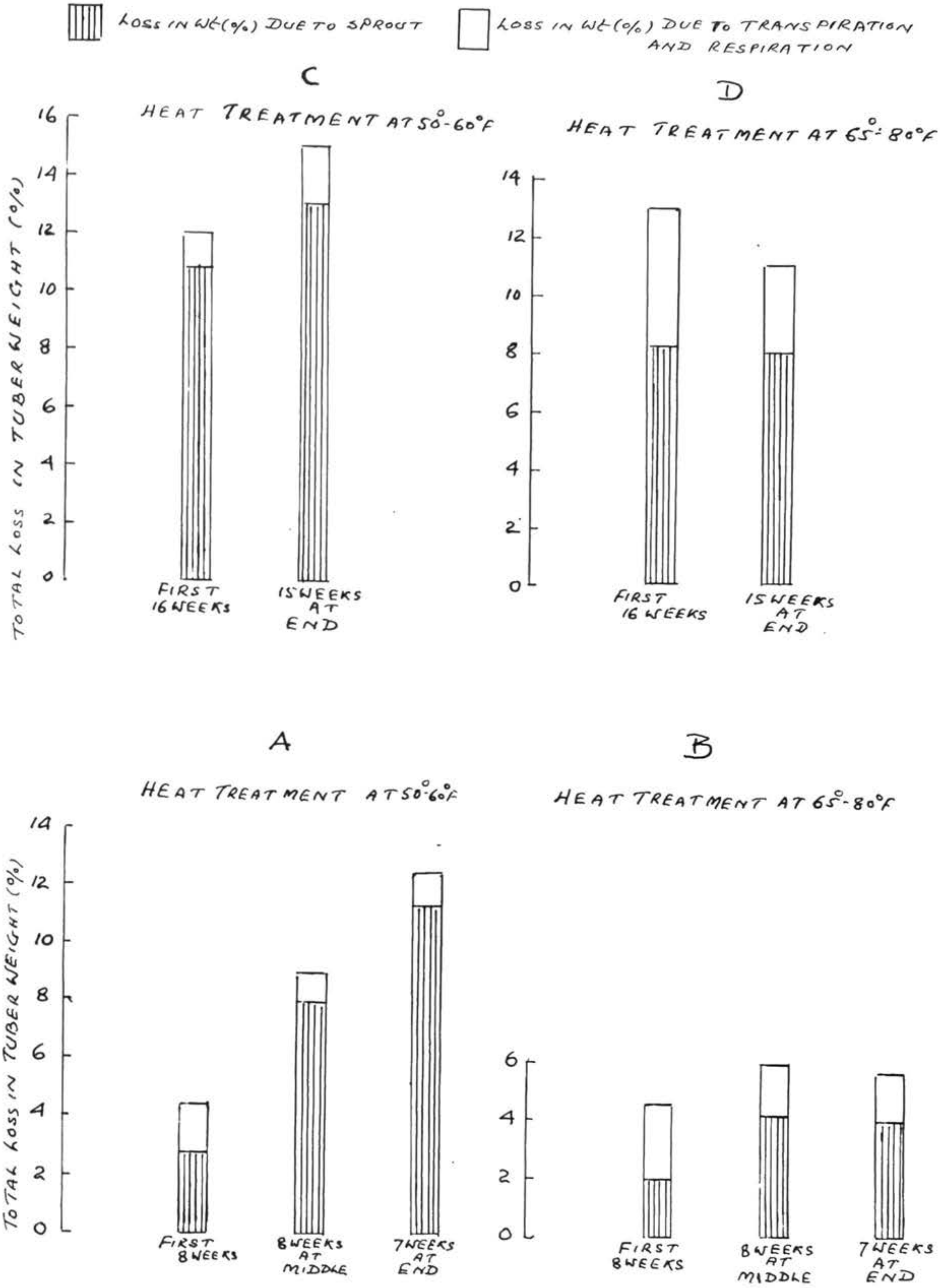
of tubers at the time when the heat treatment was applied (Table 119 and Fig. 18 A).

This result is in agreement with that of Krijthe (1958) who indicated that the germinating power of potato tubers increased with the age of the tuber and also with that of Burton (1952c) who reported that the weight of sprouts produced by the non-dormant tubers (Majestic) after 73 days at 10°C was six times as great as that after 105 days from tubers initially dormant.

Irrespective of time of heat treatment, loss in weight of tubers due to sprouting was markedly greater than losses due to transpiration and respiration, which were more or less the same for the three times of heat treatment. Although sprouting was greater with later periods of heat treatment, heat treatment during the first 8 weeks showed a tendency to give greater loss in weight due to transpiration and respiration (Table 119 and Fig. 18A). This might be attributed to the more immature condition of the tuber giving a high rate of respiration (Appleman etal 1926) and possibly to a less well developed periderm resulting in greater water loss from the tuber surface (Burton and Hann 1957b).

Total loss in weight was maximum when heat treatment was done in the 7 weeks at the end (12.47%), intermediate in 8 weeks at the middle (9.11%) and lowest in 8 weeks at the beginning (4.51%) of the storage period which may be related to the different levels of sprout loss (Table 119 and Fig. 18A).

Fig.1 EFFECT OF STORAGE AT 50°-60°F AND 65°-80°F ON LOSS IN TUBER WEIGHT(o/o) DUE TO SPROUTING, TRANSPIRATION AND RESPIRATION AFTER DIFFERENT STORAGE PERIODS.



(b) Heat Treatment at High Temperature (65°-80°F) for 8 or 7 Weeks Period

Losses in weight of tubers due to sprouting were higher when heat treatment was done during 8 weeks at the middle (4.23%) or 7 weeks at the end (4.11%) of the storage period and lowest during the first 8 weeks (2.10%) [Table 119 and Fig. 18 B]. At high temperature, however, no difference was evident between the two later periods of heat treatment (Fig. 18 B).

The loss in weight due to transpiration and respiration was more or less the same for the different times of heat treatment, although 8 weeks heat treatment at the beginning again showed a tendency to give greater loss in weight due to transpiration and respiration (Table 119 and Fig. 18 B).

At comparable times of heat treatment tubers stored at medium temperature (50°-60°F) showed more sprout development than those stored at high temperature (65°-80°F) indicating an inhibiting effect of high temperature storage on growth, as reported by Headford (1960 and 1962) [Fig. 18 A and B].

Loss in weight of tubers due to transpiration and respiration increased with an increase in storage temperature. Total loss in weight suffered by the tubers during 8 weeks or 7 weeks at 50°-60°F was greater than that at 65°-80°F for the two later periods of heat treatment on account of greater sprout growth at 50°-60°F, but

TABLE 120

Loss in wt. (%) of tubers under different heat treatments (15-16 weeks)

Storage Treatment	50°-60°F			65°-80°F		
	Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt (%)	Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt (%)
First 8 weeks at 40°F and then 15 weeks heat treatment	13.20	1.89	15.09	8.01	3.07	11.08
First 16 weeks heat treatment and then 7 weeks at 40°F	10.85	1.15	12.00	8.27	4.72	12.99

there was no difference in total weight loss between the two temperatures for the first period when sprout growth was at a minimum and other losses (transpiration and respiration) tended to be relatively high.

(c) Heat Treatment at Medium Temperature (50°-60°F) for 16 Weeks or 15 Weeks

Fifteen weeks heat treatment at the end of the storage period gave a greater loss in weight due to sprouting than 16 weeks heat treatment at the beginning of the storage period despite the shorter length of period in the former case (Table 120 and Fig. 18 C). This result also indicates that the germinating power of the tuber increases with the age.

No marked differences in weight loss due to transpiration and respiration between 16 weeks at the beginning and 15 weeks heat treatment at the end were found. The very slight increase where heat treatment was applied later may be associated with the greater amount of sprout growth exerting some effect over the period involved (Table 120 and Fig. 18 C).

(d) Heat Treatment at High Temperature (65°-80°F) for 15 or 16 Week Period

Later heat treatment showed more or less the same amount of loss in weight due to sprouting as heat treatment at the beginning of storage period. The losses of 8.01% and 8.27% show an inhibiting effect of high temperature on the rate of sprout growth of 0.53% per week and 0.51% per week respectively for later 15 weeks and beginning 16 weeks heat treatment, suggesting no marked difference in the rate of sprout growth with increased age (Table 120).

Sixteen weeks heat treatment at the beginning showed 4.72%, i.e. 0.29% per week loss in weight of tubers due to transpiration and respiration, and for the 15 weeks at the end this figure was 3.07%, i.e. 0.20% per week, thus showing no marked difference between the two times of treatments (Table 120).

While loss in weight of tubers due to transpiration and respiration increased with increase in storage temperature, at medium temperature tubers suffered a greater loss in weight due to sprouting than those stored at high temperature and the total weight loss was also greatest at medium temperature (Fig. 18 C and D).

(ii) Weight Losses During the Total Storage Period

Tubers stored at low temperature ($40^{o}F$) throughout the storage period showed least weight loss, the total loss amounting to 3.33% with less than 0.5% due to sprouting. Short periods (7-8 weeks) of exposure to heat treatment increased the weight loss, the increase being greatest at medium temperature during later periods of storage; this effect can be attributed to the increase in germinating power of the tuber with age as already indicated. At high temperature the increase was in

TABLE 121

Effect of period of heat treatment on the shrinkage of seed tubers at the time of planting

Period of Heat Treatment	50°-60°F			65°-80°F			Mean		
	Loss in wt. (%) throughout the storage period due to: Sprout	Loss in wt. (%) throughout the storage period due to: Transpiration and Respiration	Total loss in wt (%)	Loss in wt. (%) throughout the storage period due to: Sprout	Loss in wt. (%) throughout the storage period due to: Transpiration and Respiration	Total loss in wt (%)	Sprout	Transpiration and Respiration	Total loss in wt (%)
1. First 8 weeks heat treatment and then 15 weeks at 40°F	3.13	2.47	5.60	3.17	3.38	6.55	3.15	2.92	6.07
2. First 8 weeks at 40°F and then 8 weeks heat treatment and then 7 weeks at 40°F	8.10	2.39	10.49	4.23	2.73	6.96	6.16	2.56	8.72
3. First 16 weeks at 40°F and then 7 weeks heat treatment	11.34	2.03	13.37	4.15	2.84	6.99	7.74	2.44	10.18
4. First 16 weeks heat treatment and then 7 weeks at 40°F	10.85	1.68	12.53	8.27	5.27	13.54	9.56	3.47	13.03
5. First 8 weeks at 40°F and then 15 weeks heat treatment	13.20	2.69	15.89	8.01	3.65	11.66	10.60	3.17	13.77
6. Throughout (23 weeks) heat treatment	13.45	3.93	17.38	11.91	5.48	17.39	12.68	4.70	17.38
Mean	10.01	2.53	12.54	6.62	3.89	10.51	8.31	3.21	11.52
7. Throughout (23 weeks) at 40°F	0.41	2.76	3.17	0.50	2.99	3.49	0.46	2.87	3.33

general less marked due to the adverse effect of high temperature on sprout growth. Long periods (15-16 weeks) of heat treatment at high temperature gave further increases in weight loss relating to increased sprouting and losses due to respiration and transpiration. Extending the period of heat treatment at medium temperature also gave relatively high weight losses which were greater where the heat treatment was applied late due to the greater amount of sprout loss. Maximum weight loss occurred where tubers were stored throughout (23 weeks) at medium or high temperature, due to relatively high levels of sprout loss, more particularly at medium temperature, and also to relatively high losses due to transpiration and respiration, more especially at high temperature (Table 121).

In general, sprout losses tended to be greatest at medium temperature while greatest losses due to transpiration and respiration were found with high temperature storage (Table 121).

2. <u>Effect of Ventilation on Weight Loss in Storage</u>

In this study the tubers were stored in boxes with tightly fitting lids which prevented any free access of outside air. In order to determine the significance of the restriction of ventilation, the weight losses of tubers held at medium (50^{o}-$60^{o}F$) and high (65^{o}-$80^{o}F$) temperatures have been compared with those from tubers used in the previous study (Experiment 4) which were held

TABLE 122

Effect of ventilation on weight loss in storage

Temperature of Storage	Stored in Tin Boxes			Stored in Cardboard Boxes		
	Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt (%)	Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt (%)
50^{o}-60^{o}F throughout the storage period	13.45	3.93	17.38	22.31	25.85	46.07
65^{o}-80^{o}F throughout the storage period	11.91	5.48	17.39	18.32	32.92	51.24

at comparable storage temperatures without T.C.N.B. (small seed) in cardboard boxes allowing a free air flow from outside. It may be seen from Table 122 that tubers in the more freely ventilated cardboard boxes gave greater amounts of sprout growth and greater losses due to transpiration and respiration than tubers stored in tin boxes where air movement was very restricted.

The reduced sprout growth in closed containers may be related to the accumulation of volatile gases produced from the tubers which according to Burton (1952b) can suppress sprouting while the greater fresh weight loss due to transpiration would be expected with increased ventilation (Burton 1955).

C. Studies on Plant Growth and Development

1. The Rate of Plant Emergence

The average number of days to plant emergence for tubers from the various treatments are given in Appendix 90. The averages are based on 100% plant emergence with the exception of tubers held throughout the storage period at medium (50^{o}-60^{o}F) or high (65^{o}-80^{o}F) temperature which gave final emergence percentages of 60 and 70 respectively.

The data relating to the effect of different storage treatments on emergence rate was subjected to statistical analysis and for this purpose a "Germination Rate Index" (Bartlett 1937) was worked out for each treatment as described for previous experiments (Appendix 91). The analysis of variance of the results (Appendix 92) showed that the effect of treatment on the rate of plant emergence was significant. A further breakdown of the effect of treatment indicated that the period of heat treatment exerted a significant effect (Appendix 92) but that the effect of temperature (average of medium and high temperature) and the interaction of temperature and period of heat treatment were not significant.

Effect of Period of Heat Treatment on the Rate of Emergence of Plant

Where the period of heat treatment was short (7 to 8 weeks) heat treatment during the first 8 weeks of storage gave a significantly slower rate of plant emergence than

TABLE 123

Effect of periods of heat treatment on the "Germination Rate Index"

	Period of Heat Treatment	Germination Rate Index
1.	First 8 weeks heat treatment and then 15 weeks at $40^{\circ}F$	0.226
2.	First 8 weeks at $40^{\circ}F$ and then 8 weeks heat treatment and then 7 weeks at $40^{\circ}F$	0.311
3.	First 16 weeks at $40^{\circ}F$ and then 7 weeks heat treatment	0.492
4.	First 16 weeks heat treatment and then 7 weeks at $40^{\circ}F$	0.185
5.	First 8 weeks at $40^{\circ}F$ and then 15 weeks heat treatment	0.600
6.	Throughout (23 weeks) heat treatment	0.264
7.	Throughout (23 weeks) at $40^{\circ}F$	0.347

S.E. of Period of Heat Treatment ± 0.033

TABLE 124

Effect of period of heat treatment on the average number of days required for plant emergence

Period of Heat Treatment	Average number of days required in the emergence of plant
1. First 8 weeks heat treatment and then 15 weeks at 40°F	34.69
2. First 8 weeks at 40°F and then 8 weeks heat treatment and then 7 weeks at 40°F	32.95
3. First 16 weeks at 40°F and then 7 weeks heat treatment	29.30
4. First 16 weeks heat treatment and then 7 weeks at 40°F	35.10
5. First 8 weeks at 40°F and then 15 weeks heat treatment	26.73
6. Throughout (23 weeks) heat treatment	33.00
7. Throughout (23 weeks) at 40°F	31.93

heat treatment during the second 8 weeks which in turn gave a slower rate of emergence than where 7 weeks heat treatment was applied at the end of the storage period (Table 123). The average numbers of days to plant emergence in each case were 34.69, 32.95 and 29.3 respectively (Table 124). Thus tubers planted after heat treatment applied late in the storage period emerged earlier than those planted from low temperature storage following previous storage at high temperature and emergence was later the longer the period of low (40°F) temperature storage.

The results for emergence rates when the period of heat treatment was 15-16 weeks also showed that heat treatment at the end of the storage period gave significantly earlier emergence than heat treatment applied earlier (Table 123). The average number of days for plant emergence from 8 weeks at low temperature followed by 15 weeks heat treatment was 26.73 days, as opposed to 35.1 days where 16 weeks heat treatment was followed by 7 weeks at low temperature (Table 124). Thus heat treatment at the end of the storage period, i.e. just before planting, was found to stimulate early plant emergence. Moreover, lengthening the period of heat treatment at the end of the storage period from 7 weeks to 15 weeks gave a significantly faster rate of emergence with a reduction in the average number of days to emergence from 29.3 days to 26.1 days (Table 123 and 124).

Where the period of heat treatment extended throughout the storage period, however, the rate of plant emergence was adversely affected and the final plant stand was reduced (Appendix 90). Low temperature throughout the storage period proved superior to heat treatment throughout but gave a slower rate of emergence than heat treatment at the end of the storage period (7-15 weeks) [Table 123 and 124].

Heat treatment during the middle of the storage period did not give any significantly earlier emergence than storage throughout at low temperature. While 8 weeks heat treatment at the beginning of the storage period slightly delayed emergence relative to continuous low temperature and 16 weeks heat treatment early in the storage period followed by low temperature storage gave the slowest rate of plant emergence of all treatments (Table 123 and 124).

Periods of heat treatment as they affect speed of emergence may be arranged in descending order as follows:-

1. First 8 weeks at 40°F and then 15 weeks heat treatment (avg. 26.7 days).
2. First 16 weeks at 40°F and then 7 weeks heat treatment (avg. 29.7 days).
3. Throughout at 40°F (avg. 31.93 days).
4. First 8 weeks at 40°F and then 8 weeks heat treatment and then 7 weeks at 40°F (avg. 32.9 days).
5. Throughout heat treatment (avg. 33.0 days).

5. Throughout heat treatment (avg. 33.0 days).
6. First 8 weeks heat treatment and then 15 weeks at 40°F (avg. 34.69 days).
7. First 16 weeks heat treatment and then 7 weeks at 40°F (avg. 35.10 days).

N.B. Differences between brackettted treatments not significant.

2. Dry Weight of Foliage and Tubers at Different Stages of Plant Development

The dry weights (gm.) of tubers per plant recorded on the different dates of sampling for the various storage treatments are given in Appendix 93 and the analysis of variance of the data is shown in Appendix 94. The dry weight of foliage per plant on different dates of sampling has been presented in Appendix 95.

(i) Time of Lifting

As shown in Table 125 in general (average of all storage treatment) dry weight of foliage per plant increased rapidly up to the second lifting date (85 days after planting). Further growth of foliage up to the third sampling date (103 days after planting) was negligible, while senescence of leaves started after the third sampling and the dry weight of foliage per plant decreased at the final sampling (126 days after planting).

TABLE 125

Dry weight (gm.) of foliage per plant at different stages of plant development

Days after planting	Dry wt. (gm.) of foliage per plant
64 days (l_1)	19.7
85 days (l_2)	41.0
103 days (l_3)	43.5
126 days (l_4)	18.7

Dry weight of tubers increased up to the final lifting (Table 126). Maximum dry weight production of tubers occurred between the second and third sampling when the growth rate was 3.8 gms. per plant per day compared with 2.9 gms. per plant per day between third and fourth sampling date and 2.6 gms. per plant per day between the first and second sampling dates. Thus maximum crop increases were found between the 12th and 15th week after planting (Table 126). Davidson (1958a) having previously reported that maximum crop increases occurred between the 12th and 16th weeks after planting.

TABLE 126

Dry weight (gm.) of tubers per plant at different stages of plant development

Days after planting	Dry wt. (gm.) of tuber per plant
64 days (l_1)	12.1
85 days (l_2)	72.8
103 days (l_3)	139.6
126 days (l_4)	198.3

S.E. of Date of lifting $\pm$5.02

(ii) Effect of Different Storage Treatments on Dry Matter Production of Tubers and Foliage at Various Stages of Plant Growth

From Appendix 94 it may be seen that with regard to

Fig.19 EFFECT OF HEAT TREATMENT AT 50°-60°F AND 65°-80°F ON THE DRY MATTER PRODUCTION OF TUBERS AND FOLIAGE PER PLANT AT DIFFERENT STAGES OF PLANT DEVELOPMENT.

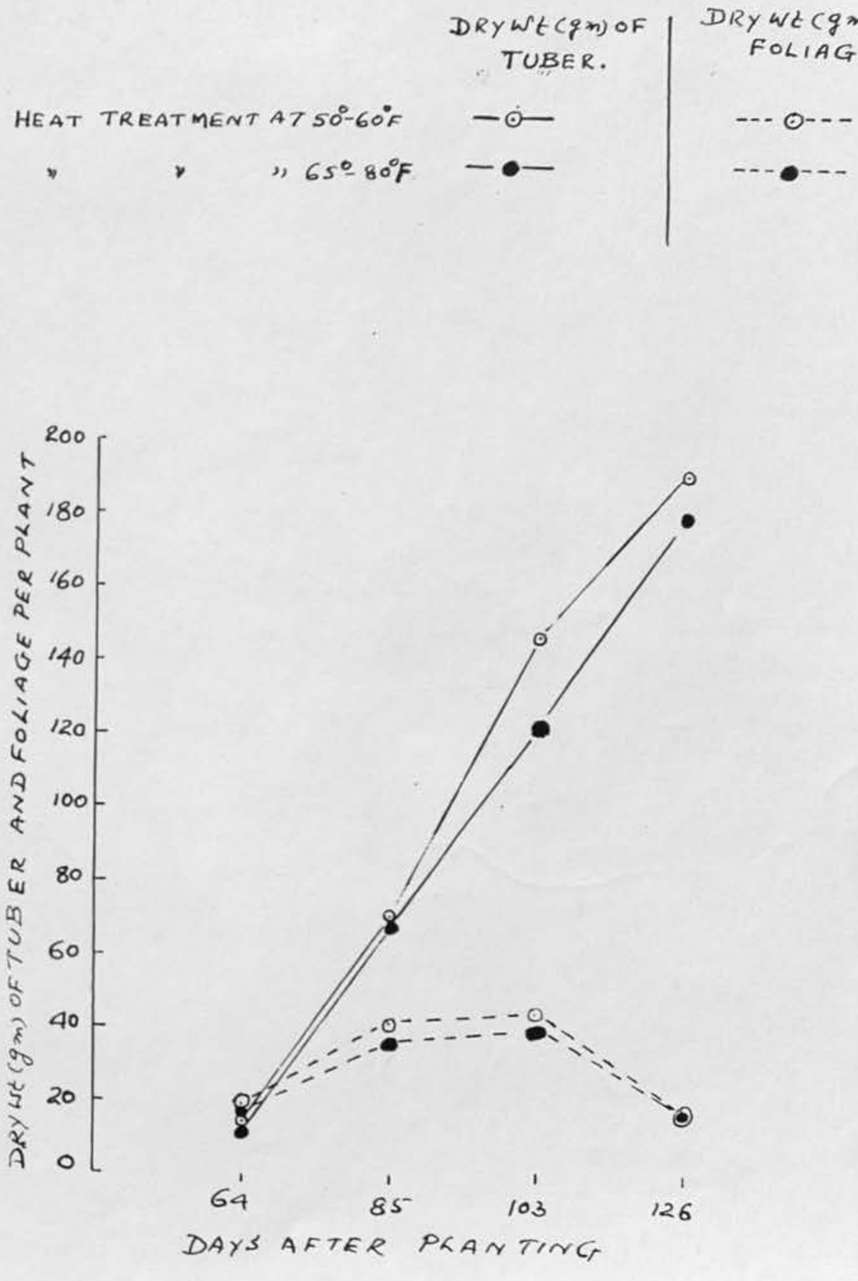


TABLE 127

EFFECT OF THE TEMPERATURE OF STORAGE ON DRY WT(g) OF TUBERS PER PLANT AT VARYING STAGES OF PLANT DEVELOPMENT

Temperature of storage	Dry wt(g) of tuber per plant at different dates of lifting				
	l_1	l_2	l_3	l_4	Mean
Medium (50°-60°F.)	14.4	69.8	146.0	189.7	105.0
High (65°-80°F.)	11.00	68.8	120.9	178.2	94.7

S.E. of Temperature ± 3.25
S.E. of Temperature x Date of lifting ± 6.50

TABLE 128

EFFECT OF THE TEMPERATURE OF STORAGE ON DRY WT(g) OF FOLIAGE PER PLANT AT VARYING STAGES OF PLANT DEVELOPMENT

Temperature of storage	Dry wt(g) of foliage per plant at different dates of lifting				
	l_1	l_2	l_3	l_4	Mean
Medium (50°-60°F.)	19.4	40.7	43.7	17.7	30.3
High (65°-80°F.)	19.1	35.6	39.4	17.8	27.7

N.B.

l_1 = lifted 64 days after planting
l_2 = " 85 " " "
l_3 = " 103 " " "
l_4 = " 126 " " "

dry weight (gm.) of tuber, the main effects of temperature and periods of heat treatment were significant, but that significant interactions occurred between temperature and period of heat treatment and between period of heat treatment and date of lifting.

The main effect of temperature (average of period of heat treatment) indicated that heat treatment at medium temperature (50^{o}-60^{o}F) gave a significantly greater dry weight production of tubers per plant than at high temperature (65^{o}-80^{o}F) [Table 127 and Fig. 19], but comparing the two temperature levels for the different periods of heat treatment the differences in favour of medium temperature were only significant when heat treatment was applied during the last seven weeks of storage (Treatment 3) or during the the first 16 weeks (Treatment 4) [Table 129]. It may also be noted that medium temperature treatments in general formed more tubers between 3.5 cm. and over 5 cm. diameter (Appendix 96) and produced more dry matter of tuber and foliage than high temperature treatment (Table 127, 128 and Fig. 19).

Where the period of heat treatment was short (7-8 weeks) the time of heat treatments did not show any significant effect on dry weight production of tubers per plant averaged for the two temperature levels and dates of lifting (Table 129). However, where high temperature (65^{o}-80^{o}F) treatment was applied during the last seven weeks of storage tuber yields tended to be less and the

TABLE 129

Effect of different periods of heat treatment at high and medium temperature on dry weight of tuber per plant

Period of Heat Treatment	Dry wt. (gm.) of tuber per plant		Mean
	50°-60°F	65°-80°F	
1. First 8 weeks heat treatment and then 15 weeks at 40°F	129.0	121.9	125.5
2. First 8 weeks at 40°F and then 8 weeks heat treatment and then 7 weeks at 40°F	127.4	129.5	128.4
3. First 16 weeks at 40°F and then 7 weeks heat treatment	129.3	107.1	118.2
4. First 16 weeks heat treatment and then 7 weeks at 40°F	100.8	58.82	79.8
5. First 8 weeks at 40°F and then 15 weeks heat treatment	125.1	140.0	132.5
6. Throughout (23 weeks) heat treatment	18.5	11.20	14.8
Mean	105.0	94.7	
7. Throughout (23 weeks) at 40°F	141.3	140.1	140.7

S.E. of Period of Heat Treatment ± 5.6

S.E. of Temperature x Period of Heat Treatment ± 7.9

TABLE 130

Effect of different storage treatments on dry weight (gm.) of foliage per plant

Period of Heat Treatment	Dry wt. (gm.) of foliage per plant		Mean
	50^{o}-$60^{o}F$	65^{o}-$80^{o}F$	
1. First 8 weeks heat treatment and then 15 weeks at $40^{o}F$	42.7	36.0	39.3
2. First 8 weeks at $40^{o}F$ and then 8 weeks heat treatment and then 7 weeks at $40^{o}F$	38.6	35.2	36.9
3. First 16 weeks at $40^{o}F$ and then 7 weeks heat treatment	35.7	29.5	32.6
4. First 16 weeks heat treatment and then 7 weeks at $40^{o}F$	30.7	23.5	27.1
5. First 8 weeks at $40^{o}F$ and then 15 weeks heat treatment	31.0	37.5	34.2
6. Throughout (23 weeks) heat treatment	3.4	4.5	3.9
Mean	30.3	27.7	
7. Throughout (23 weeks) at $40^{o}F$	40.8	41.20	41.0

reduction was significant in comparison with medium temperature treatment at the same time and with high temperature treatment for the second eight weeks period (Table 129): this may be due to a smaller amount of dry weight of foliage in last seven weeks heat treatment at high temperature (Table 130). During early plant development in the field, heat treatment during the last seven weeks period of storage (average of temperature) was found to give earlier plant emergence (Table 123 and 124) and tended to give high yields of tubers on the first two sampling (64 and 85 days after planting) dates compared with heat treatment applied during the first or second eight weeks storage period, but the rate of growth increment fell off more rapidly and final yields were significantly less than for the other two periods of heat treatment (Table 131). It may be seen from Appendix 96 and Table 132 respectively that the late seven weeks heat treatment produced fewer tubers of 3.5 cm. and over 5 cm. diameter at the last two sampling dates and also gave smaller amounts of foliage during different stages of plant growth compared with those subjected to heat treatment during the first or second eight weeks storage period.

When the period of heat treatment was increased from 7-8 weeks to 15-16 weeks, 16 weeks heat treatment (average of two temperature levels) at the beginning of the storage period gave significantly lower tuber production than heat treatment applied during the last 15 weeks, the effect being more marked at high temperature (Table 129). The difference in favour of late heat treatment for higher dry weight of tubers was evident at each date of sampling and significant for the final three sampling dates (Table 131). Late heat treatment for 15 weeks also gave a larger number of tubers of higher diameter (over 5 cm.) [Appendix 96], and greater amounts of foliage (Table 130 and 132) compared with early heat treatment.

In comparing short periods (7-8 weeks) of heat treatment with longer periods (15-16 weeks) there was no significant difference between the results for short periods of treatment at varying times and heat treatment during the last 15 weeks of storage, with the exception of heat treatment at high temperature (65^{o}-80^{o}F) during the last seven weeks of storage which tended to give lower dry weight production of tubers (Table 129). In the case of early heat treatment for 16 weeks, however, yields of tuber (Table 129) and amount of foliage (Table 130) were consistently lower than for all of the previous treatments.

Heat treatment applied throughout the storage period (23 weeks) was found to be the least favourable for plant development, giving late emergence (Table 123 and 124) and the lowest yields of tuber (Table 129) and foliage (Table 130) than any other treatment. In some cases the mother tuber exhibited a 'little potato' effect with no aerial growth and small tubers formed directly from stolons.

TABLE 131

Effect of period of heat treatment on dry weight of tuber per plant at different stages of plant development

Period of Heat Treatment	Dry wt. (gm.) of tuber per plant at different dates of lifting			
	l_1	l_2	l_3	l_4
1. First 8 weeks heat treatment and then 15 weeks at 40°F	8.9	82.5	166.4	244.1
2. First 8 weeks at 40°F and then 8 weeks heat treatment and then 7 weeks at 40°F	13.0	83.9	167.2	249.8
3. First 16 weeks at 40°F and then 7 weeks heat treatment	17.0	102.6	146.6	106.6
4. First 16 weeks heat treatment and then 7 weeks at 40°F	7.2	41.7	122.8	147.5
5. First 8 weeks at 40°F and then 15 weeks heat treatment	25.7	97.4	175.5	231.5
6. Throughout (23 weeks) heat treatment	4.5	7.9	22.5	24.5
7. Throughout (23 weeks) at 40°F	8.6	94.0	176.3	283.9

S.E. of Date of Lifting x Period of Heat Treatment ±11.2

N.B. l_1 = 64 days after planting
l_2 = 85 days after planting
l_3 = 103 days after planting
l_4 = 126 days after planting

TABLE 132

Effect of period of heat treatment on dry weight (gm.) of foliage per plant at different dates of lifting

Period of Heat Treatment	Dry wt. (gm.) of foliage per plant at different dates of lifting			
	l_1	l_2	l_3	l_4
1. First 8 weeks heat treatment and then 15 weeks at $40^{o}F$	22.5	53.7	57.6	23.7
2. First 8 weeks at $40^{o}F$ and then 8 weeks heat treatment and then 7 weeks at $40^{o}F$	22.3	53.4	51.1	20.9
3. First 16 weeks at $40^{o}F$ and then 7 weeks heat treatment	21.4	45.2	42.2	21.4
4. First 16 weeks heat treatment and then 7 weeks at $40^{o}F$	15.3	28.0	47.0	18.1
5. First 8 weeks at $40^{o}F$ and then 15 weeks heat treatment	29.3	43.8	44.5	19.5
6. Throughout (23 weeks) heat treatment	1.3	4.7	6.9	2.9
7. Throughout (23 weeks) at $40^{o}F$	25.8	58.3	55.4	24.5

N.B. l_1 = 64 days after planting
l_2 = 85 days after planting
l_3 = 103 days after planting
l_4 = 126 days after planting

Fig.20 EFFECT OF PERIODS OF HEAT TREATMENT ON THE DRY MATTER PRODUCTION OF TUBERS PER PLANT AT DIFFERENT STAGES OF PLANT DEVELOPMENT.

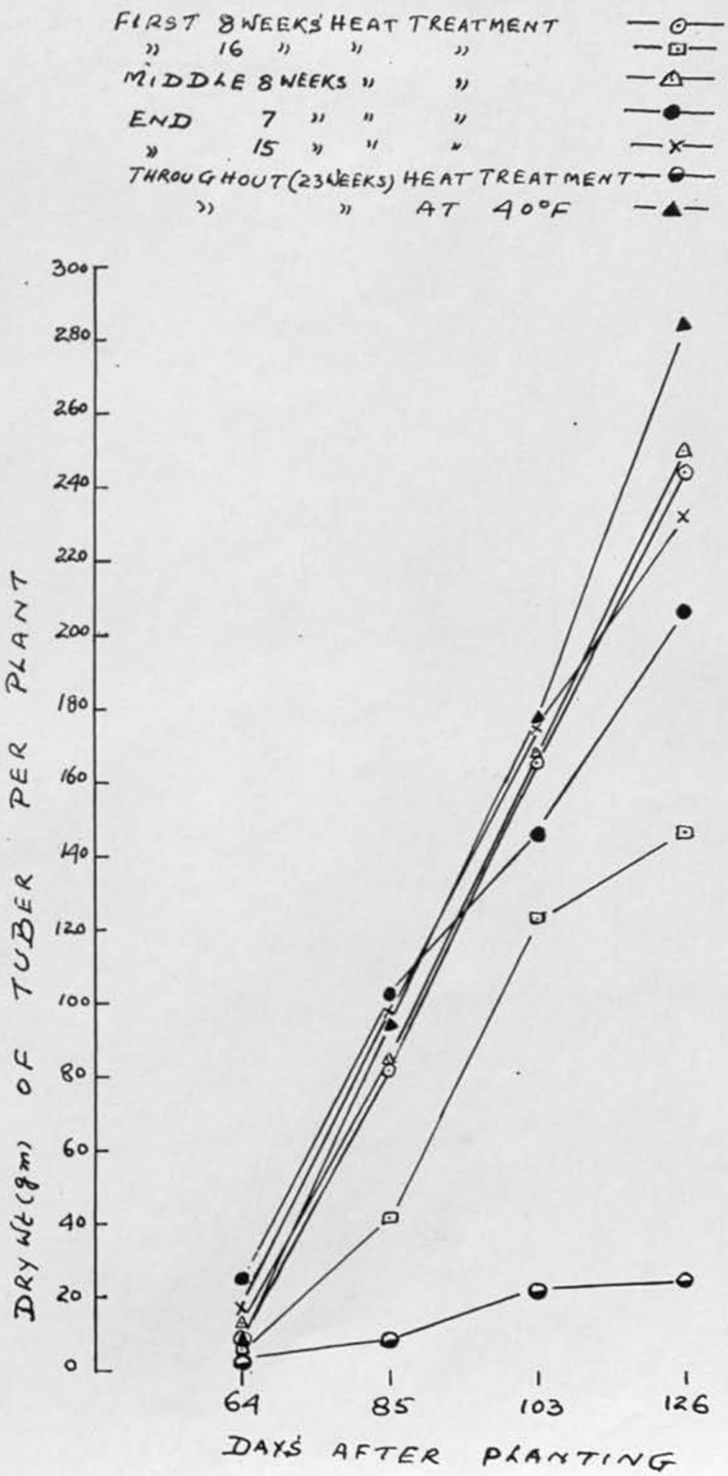
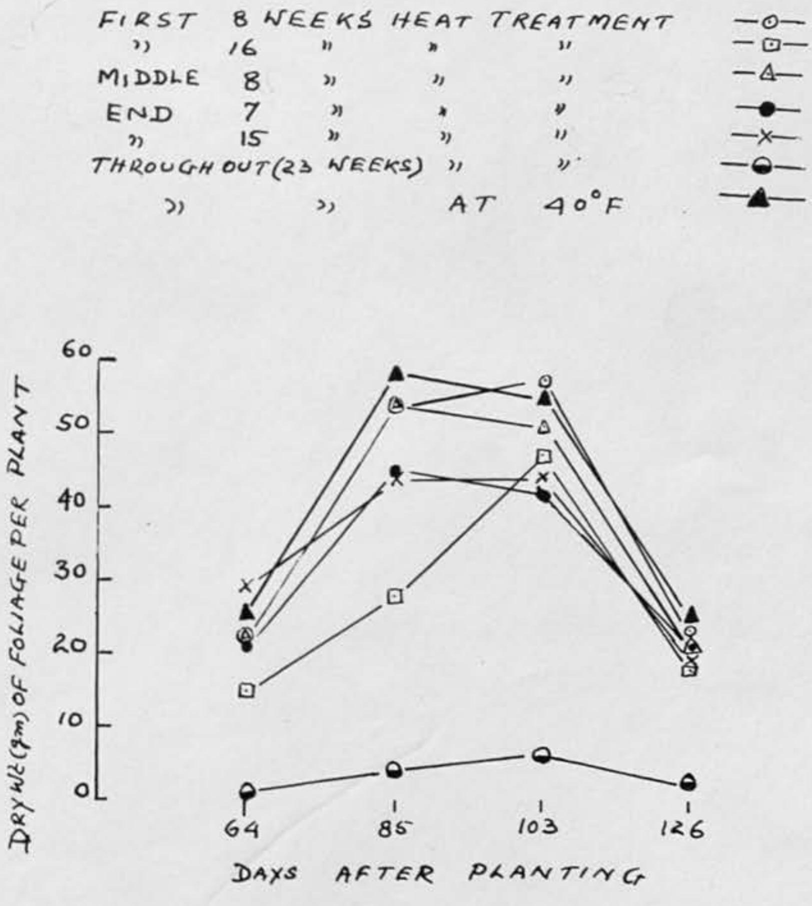


Fig.21 EFFECT OF PERIODS OF HEAT TREATMENT ON THE DRY MATTER PRODUCTION OF FOLIAGE PER PLANT AT DIFFERENT STAGES OF PLANT DEVELOPMENT.



Tubers held at low temperature throughout the storage period gave the highest yield of tubers (Table 129). The increases above other treatments were significantly greater in comparison with early 16 weeks and heat treatment throughout the storage period for the last three dates of lifting and at the final date of lifting differences in favour of low temperature storage for higher yield of tubers were significant in comparison with all other treatments (Table 131). Thus while late heat treatment (7 weeks and 15 weeks) gave earlier emergence (Table 123 and 124) and tended to give earlier tuber production than tubers planted from low temperature storage, the rate of increment appeared to fall more rapidly and continued low temperature storage gave the most sustained increment in tuber yield (Table 131 and Fig. 20). Growth of foliage of tubers stored continuously at low temperature was relatively high throughout the growing period compared with that from tubers subjected to heat treatment before planting (Table 132 and Fig. 21).

D. DISCUSSION

EXPERIMENT 5

Growth of Sprouts as Influenced by the Age of Tuber and the Temperature of Storage

The results of Experiment 5 indicate that the growth in weight of sprouts may be related to the age of the tuber and the temperature of the storage environment.

Dealing firstly with age, it was found that the amount of sprout growth from tubers exposed to temperatures suitable for growth for a fixed period before or after low temperature storage increased with the age of the tuber after harvest. Thus with tubers subjected to periods of higher temperatures (50^{o}-60^{o}F or 65^{o}-80^{o}F) at varying times during the storage season, the amount of sprout growth was maximum when this occurred late in the storage season, intermediate during mid season and lowest during the beginning of storage. This result confirms the views of Krijthe (1958) who indicated that from the time of lifting onwards to a certain stage the "Germinating power" of the potato tuber (as measured by the weight of sprouts produced during a period of four weeks at a constant temperature at 20^{o}C following previous storage at 2^{o}C) increases with age.

The small amount of sprout growth during the beginning of the storage season may be related to the initial dormancy of the tubers. Thus some time was required for completion of the period of rest or dormancy and as a result tubers gave a smaller amount of sprout growth compared with those stored at 40°F before heat treatment. In fact tubers subjected to heat treatment at the end of the storage period tended to show sprout development at low temperature (40°F) prior to storage at higher temperatures. Burton (1952c) has reported that the weight of sprouts produced by the non-dormant tubers (stored previously at 5°C from October to February) after 73 days at 10°C was six times as great as that produced after 105 days at the same temperature by tubers initially dormant.

In the present experiment it may be noted that increase in sprout growth associated with age of tuber did not apply when the heat treatment was carried out at 65°-80°F for a long period (15 weeks) at the end of the storage period compared with heat treatment at the beginning, suggesting an inhibiting effect of high temperature on sprout growth.

Apart from the age of the tuber, the growth of sprouts was influenced greatly by the temperature of storage. Thus at comparable times of heat treatment tubers stored at 50°-60°F gave a greater sprout growth than those stored at 65°-80°F. Barker (1937) reported that increase in the rate of sprout growth occurred by increasing the temperature of the storage from 41°F to 59°F but above that the increase was less marked. According to Owers (1960) and later Shotton (1961) sprout growth increased with increase in temperature from 45°F to 55°F in the case of Arran Pilot or to 65°F in the case of Majestic and King Edward, but further increase in temperature to 75°F resulted in a decrease in sprout growth. Headford (1960 and 1962) also reported the inhibiting effect of high temperature (68°F, 77°F and 86°F) on sprout growth in Arran Pilot and King Edward. In the previous experiment (Experiment 4) the inhibiting effect of high temperature (65°-80°F) storage on sprout growth has also been shown.

Growth of sprouts in weight was also influenced by the movement of air in the storage atmosphere. Thus tubers stored in boxes with tightly fitting lids at 50°-60°F or at 65°-80°F produced less sprout growth than comparable tubers stored in freely ventilated cardboard boxes. This result is in agreement with that of Burton (1952b) who showed that volatile melabolic substances produced by the potato prevent sprouting if they accumulate during storage.

Growth and Plant Development in the Field

(a) Rate of Plant Emergence

Although tubers of all storage treatments were planted without any sprouts, the rate of plant emergence was found to be related to the temperature of storage. Thus heat treatment (averaged for 50°-60°F and 65°-80°F) at the end of the storage period (7 or 15 weeks) i.e. just before planting, hastened plant emergence. On the other hand, heat treatment at the beginning (8 or 16 weeks) or middle (8 weeks) of the storage period followed by low temperature (40°F) did not result in earlier plant emergence than storage throughout at low temperature. It seems that exposure to low temperature following heat treatment and desprouting caused a retardation in subsequent plant development.

Early plant emergence in seed tubers subjected to heat treatment at the end of the storage period may be related to the effect of temperature on the physiological development of the tuber reserves, higher temperatures advancing physiological development and stimulating subsequent sprout growth. It has been shown by many earlier workers (Peacock and Wright 1927, Stuart and Lombard 1929) that dormant tubers held at high temperature (50°-70°F) for a short period before planting produced plant above ground earlier than those stored at low temperature (32°F). McCubbin (1941) also reported that desprouted seed tubers (sprouted for one month before planting) emerged earlier than dormant seed (stored at 36°F).

The stimulating effect of high temperature storage before planting was not evident when the heat treatment extended throughout the storage period. In this case incomplete plant stands were obtained and the emergence rate of plants that did emerge was slower than that for low temperature storage.

(b) <u>Growth of Foliage and Tuber Yield at Different Stages of Plant Development</u>

While heat treatment at the end (7 or 15 weeks) of the storage period gave earlier plant emergence and tended to give earlier tuber production than seed tubers planted from low temperature, the rate of increment appeared to fall more rapidly and continued low temperature storage gave the most sustained increment in tuber yield per plant (in terms of dry weight). In fact, seed tubers subjected to heat treatment before planting, irrespective of time or period of heat treatment, gave a significantly smaller tuber yield per plant at final lifting than those stored throughout at low temperature. Smaller tuber yields at final lifting associated with heat treatment before planting may be related to the restricted growth of foliage at different stages of plant development which in turn might have restricted the growth of tubers at final lifting. Making particular reference to removal of sprouts at the time of planting, McCubbin (1941) has shown that desprouted seed (sprouted for one month at 50°F in light or darkness and desprouted at the time of planting) gave a greater tuber yield at different stages of plant development than those stored throughout at low temperature (39°F) but with regard to final yield the author considered that it would depend primarily on time of planting, length of the growing season and climatic conditions. With early planting or a growing season sufficiently long to permit plants of the two seed treatments (desprouted and dormant) to attain complete maturity under equally favourable climatic conditions, yield would be equal. With late planting or a short growing season where the growth of plants was impeded by late blight or frost, yield would probably be greater from desprouted seed than dormant seed.

From the present study it would appear that with an early variety the effect of high temperature storage, even for a short period may have an adverse effect on final yield in curtailing the effective growing season during a period when the potential for assimilation is still high. Thus where plants are slower in reaching maturity following low temperature storage they may show a benefit from delayed leaf senescence in final yield.

Westover (1928) has shown that removal of sprouts once (stored for 48 days at 65°F, desprouted and then transferred to 39°F until planting) caused 6% loss in weight before planting and gave a non-significant reduction in yield compared with unsprouted seed (stored throughout at 39°F) where 1.3% loss in weight was sustained before planting. The reduction in yield was significant when sprouts were removed twice (desprouted once after 48 days and again after 26 days at 65°F and then transferred to 39°F until planting) causing a loss in weight of 11.3%, or more than twice. In the present experiment it has been shown that tubers subjected to heat treatment (averaged for two temperatures) before planting had 6.07% (Minimum) to 17.38% (Maximum) loss in weight and gave a significant reduction in final yield compared with seed stored throughout at 40°F where 3.33% loss in weight was sustained and a significant negative correlation ($r = -0.765$) between weight loss of the seed tuber and final tuber yield was found. Although it might be expected that weight loss of the seed tubers has a weakening effect on subsequent plant growth, the effect of temperature on subsequent plant development must also be considered and higher temperatures during storage have reduced final yield by hastening plant maturity resulting in restricted foliage development.

E. CONCLUSIONS

EXPERIMENT 5

Studies were carried out on the effect of exposure of seed tubers of Arran Pilot held at 40°F to higher temperature (50°-60°F or 65°-80°F) for varying periods at varying times during the storage season on sprout growth during the period of heat treatment and on subsequent plant growth and development and final crop yield (in terms of dry weight of tuber per plant) after desprouting before planting.

1. The amount of sprout growth from tubers exposed to higher temperatures (50°-60°F or 65°-80°F) for a fixed period of storage increased with the age of the tuber after harvest.

2. Weight losses due to sprout growth during storage were least at 40°F. With higher storage temperature (50°-60°F) sprout growth was increased but a further increase in temperature to 65°-80°F resulted in less sprouting. In general, loss in tuber weight due directly to sprouting tended to be greatest at 50°-60°F while weight losses due to transpiration and respiration varied directly with the increase in storage temperature from 40°F to 65°-80°F.

3. As losses in tuber weight due to sprouting formed the major source of loss in this experiment, the total weight losses were minimum at 40°F, intermediate at 65°-80°F and maximum at 50°-60°F.

4. Sprouting was reduced by storage in containers having

restricted ventilation where it was assumed that volatile metabolic substances produced by tubers suppressed sprouting by accumulating in the storage atmosphere.

5. At higher temperature (50°-60°F or 65°-80°F) tubers stored in ventilated containers suffered greater total loss in weight than those stored in a condition where free access of outside air was very restricted.

6. Heat treatment (averaged for 50°-60°F and 65°-80°F) at the end of the storage period (7 or 15 weeks) and desprouting at the time of planting hastened plant emergence, whereas heat treatment at the beginning (8 or 16 weeks) or middle (8 weeks) of the storage period followed by low temperature (40°F) storage until planting time did not result in earlier plant emergence than storage throughout at low temperature (40°F).

7. Heat treatment at the end of the storage period tended to give earlier tuber production (in terms of dry weight of tuber per plant) up to 85 days after planting than tubers planted from low temperature (40°F) but the rate of increment appeared to fall more rapidly and continued low temperature storage gave the most sustained increment in tuber yield (dry weight of tuber per plant) at final lifting.

8. Tubers stored throughout at low temperature (40°F) showed greater growth of foliage (in terms of dry weight per plant) at varying stages of plant development than those subjected to heat treatment before planting.

9. Heat treatment at 50°-60°F or 65°-80°F throughout the storage period followed by desprouting at the time of planting proved most unfavourable for plant development, giving incomplete plant stands, low growth of foliage and a high incidence of "little tuber".

10. In general, dry weight of foliage per plant (averaged for all storage treatment) was maximum between 85 and 103 days (i.e. 25th July - 12th August) after planting and after that senescence of leaves commenced.

Maximum dry weight production of tubers (averaged for all storage treatment) occurred between 85 and 103 days after planting, i.e. 25th July - 12th August, (3.80 gms. per plant per day) intermediate between 103 and 126 days after planting, i.e. 12th August - 14th September, (2.90 gms. per plant per day) and lowest between 64 and 85 days after planting, i.e. 4th July - 25th July (2.60 gms. per plant per day).

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A P P E N D I C E S

APPENDIX 1

TEMPERATURE OF GLASSHOUSE AND STORAGE BUILDING
[illegible] PERIOD

Month	Glasshouse		Storage Building	
	Minimum °F	Maximum °F	Minimum °F	Maximum °F
October	52	56	40	50
November	53	58	40	47
December	53	58	39	45
January	51	58	36	44
February	48	60	33	43
March	49	60	38	45
April	51	70	-	-

APPENDIX 2

METEOROLOGICAL OBSERVATIONS 1960

Month	Temperature °F			Rainfall (Inches)		Sun Shine Hours
	Minimum	Maximum	Difference from Average	Total Inch	Difference from Average	
April	39.0	54.0	+4.2	1.17	-0.82	121.9
May	52.1	56.0	+4.4	1.17	-0.84	134.1
June	54.0	58.4	+4.0	1.25	-0.84	179.4

EXPERIMENT 1 - APPENDIX 3 to 17

APPENDIX 3

SPROUTS PER EYE, SPROUTED EYES AND SPROUTS PER TUBER AT THE TIME OF SPROUTING.

Tr. No.	Storage period from 19 October and storage treatment.	Date of Sprouting	Arran Pilot			Majestic		
			No.[1] Sp. P.E.	No.[2] Sptd. E.P.T.	No.[3] Sp. P.T.	No. Sp. P.E.	No. Sprd. E.P.T.	No. Sp. P.T.
1.	Sprouted from the beginning	20.10.59	0	0	0	0	0	0
2.	31 days with T.C.N.B.	19.11.59	0	0	0	0	0	0
3.	" " at 40°F.	"	0	0	0	0	0	0
4.	57 days with T.C.N.B.	15.12.59	1.0	2.88	2.88	0	0	0
5.	" " at 40°F.	"	1.0	2.00	2.00	0	0	0
6.	85 days with T.C.N.B.	12.1.60	1.0	1.71	1.71	0	0	0
7.	" " at 40°F.	"	1.0	2.62	2.62	0	0	0
8.	113 days with T.C.N.B.	9.2.60	1.39	1.67	2.33	0	0	0
9.	" " at 40°F.	"	1.17	6.83	8.00	0	0	0
10.	141 days with T.C.N.B.	8.3.60	1.15	6.50	7.50	0	0	0
11.	" " at 40°F.	"	1.30	7.67	10.00	1.00	1.75	1.75
12.	141 days without T.C.N.B. in storage building.	8.3.60	1.05	6.58	6.92	Visible Sprouting		

N.B.

1. No. Sp. P.E. = Number of sprouts per eye.
2. No. Sptd. E.P.T. = Number of sprouted eyes per tuber.
3. No. Sp. P.T. = Number of sprouts per tuber.

APPENDIX 4

EFFECT OF VARYING PERIODS OF LOW TEMPERATURE (40°F) STORAGE AND OF T.C.N.B. TREATMENT ON THE NUMBER OF SPROUTS PER TUBER AT THE END OF THE SPROUTING PERIOD (17th APRIL)

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. <u>Variety</u>	1	165.014	165.014	12.63 **
2. <u>Treatment</u>	11	2479.028	225.366	17.25 **
(a) Treatment 1 vs Treatments 2-12	1	479.111	479.111	36.67 **
(b) Treatment 12 vs Treatments 2-11	1	96.983	96.983	7.42 **
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	48.600	48.600	3.72
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	1516.767	379.191	29.02 **
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	337.567	84.391	6.46 **
3. <u>Treatment x Variety</u>	11	812.569	73.869	5.65 **
(a) Treatment 1 vs Treatments 2-12	1	84.698	84.698	6.48 *
(b) Treatment 12 vs Treatments 2-11	1	50.188	50.188	3.84 *
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	109.350	109.350	8.37 **
(d) Time of Sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	313.768	78.442	6.00 **
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	254.565	63.641	4.87 **
Error	264	3449.334	13.065	
Total	287	6905.945		

** Significant at 1%   * Significant at 5%

APPENDIX 5

SPROUTS PER TUBER AT THE END OF THE SPROUTING PERIOD IN LIGHT

Period of Storage Before Sprouting in Light	With T.C.N.B.	At 40° F i.e. No T.C.N.B.	Mean
31 days i.e. sprouted on 19.11.59	9.25	10.46	9.85
57 days i.e. sprouted on 15.12.59	11.17	9.87	10.52
85 days i.e. sprouted on 12.1.60	11.46	13.25	12.35
113 days i.e. sprouted on 9.2.60	15.62	14.33	14.97
141 days i.e. sprouted on 8.3.60	18.83	13.92	16.37
Mean	13.27	12.37	

1. S.E. of Treatment with T.C.N.B. or no T.C.N.B. $\pm$ 0.33.
2. S.E. of Time of Sprouting $\pm$0.52.
3. S.E. of Time of Sprouting x Treatment with T.C.N.B. and no T.C.N.B. $\pm$ 0.74.

APPENDIX 6

EFFECT OF VARYING PERIODS OF LOW TEMPERATURE (40°F) STORAGE AND OF T.C.N.B. TREATMENT ON THE NUMBER OF SPROUTED EYES PER TUBER AT THE END OF SPROUTING PERIOD IN LIGHT (17th APRIL)

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. Variety	1	16.055	16.055	5.85 **
2. Treatment	11	139.708	12.700	4.63 **
(a) Treatment 1 vs Treatments 2-12	1	17.284	17.284	6.28 *
(b) Treatment 12 vs Treatments 2-11	1	0.237	0.237	-
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	26.004	26.004	9.47 **
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	75.000	18.750	6.83 **
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	21.183	5.295	1.93
3. Treatment x Variety	11	63.278	5.752	2.09 **
(a) Treatment 1 vs Treatments 2-12	1	8.491	8.491	3.09
(b) Treatment 12 vs Treatments 2-11	1	11.866	11.866	4.32 *
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	5.705	5.705	2.08
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	21.150	5.287	1.93
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	16.066	4.016	1.46
Error	264	724.834	2.745	
Total	287	943.875		

** Significant at 1%   * Significant at 5%

APPENDIX 7

VARIETAL DIFFERENCES IN SPROUTING EYES PER TUBER

Period of storage before sprouting in light.	Arran Pilot			Majestic		
	With T.C.N.B.	At 40°F. i.e. no T.C.N.B.	Mean	With T.C.N.B.	At 40°F. i.e. no T.C.N.B.	Mean
31 days i.e. sprouted on 19.11.59.	6.67	8.33	7.50	7.92	7.58	7.75
57 days i.e. sprouted on 15.12.59	6.67	7.75	7.21	7.42	6.92	7.17
85 days i.e. sprouted on 12.1.60.	6.92	8.75	7.83	6.50	8.17	7.33
117 days i.e. sprouted on 9.2.60.	8.50	9.25	[illegible]	8.25	8.75	8.50
141 days i.e. sprouted on 8.3.60.	9.33	8.92	9.12	7.42	7.83	7.62
Mean.	7.63	8.67		7.50	7.85	

S.E. of Variety x Treatment with T.C.N.B. and no T.C.N.B. ± 0.21

S.E. of Variety x Time of sprouting ± 0.33

S.E. of Variety x Time of sprouting x Treatment with T.C.N.B. and no T.C.N.B. ± 0.48.

APPENDIX 8

EFFECT OF VARYING PERIODS OF LOW TEMPERATURE (40°F) STORAGE AND OF T.C.N.B. TREATMENT ON THE NUMBER OF SPROUTS PER EYE AT THE END OF THE SPROUTING PERIOD (17th APRIL)

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. Variety	1	0.720	0.720	6.79 **
2. Treatment	11	23.627	2.147	20.25 **
(a) Treatment 1 vs Treatments 2-12	1	4.925	4.925	46.46 **
(b) Treatment 12 vs Treatments 2-11	1	0.927	0.927	8.74 **
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	3.083	3.083	29.08 **
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	12.515	3.128	29.51 **
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	2.177	0.544	5.13 **
3. Treatment x Variety	11	8.215	0.746	7.04 **
(a) Treatment 1 vs Treatments 2-12	1	0.458	0.458	4.32 *
(b) Treatment 12 vs Treatments 2-11	1	2.428	2.428	22.91 **
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	2.687	2.687	25.35 **
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	1.504	0.376	3.55 **
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	1.138	0.284	2.68 *
Error	264	28.026	0.106	
Total	287	60.588		

** Significant at 1% * Significant at 5%

APPENDIX 9

SPROUTS PER EYE AT THE END OF THE SPROUTING PERIOD

Period of Storage Before Sprouting in Light	T.C.N.B.	No T.C.N.B. i.e. 40°F	Mean
1. 31 days i.e. sprouted on 19.11.59	1.26	1.32	1.29
2. 57 days i.e. sprouted on 15.12.59	1.57	1.34	1.45
3. 85 days i.e. sprouted on 12.1.60	1.72	1.55	1.64
4. 113 days i.e. sprouted on 9.2.60	1.85	1.61	1.73
5. 141 days i.e. sprouted on 8.3.60	2.22	1.68	1.95
Mean	1.72	1.50	

1. S.E. of Treatment with T.C.N.B. and no T.C.N.B. ±0.029.
2. S.E. of Time of Sprouting ±0.046.
3. S.E. of Time of Sprouting x Treatment with T.C.N.B. and no T.C.N.B. ± 0.06.

APPENDIX 10

EFFECT OF VARYING PERIODS OF LOW TEMPERATURE AND T.C.N.B. STORAGE ON THE LENGTH OF SPROUTS

Tr. No.	Storage Period from 19th October and Storage Treatment	Date of Sprouting	Arran Pilot				Majestic			
			1-10 mm.	11-20 mm.	Over 20 mm.	Total	1-10 mm.	11-20 mm.	Over 20 mm.	Total
1.	Sprouted throughout in light	22.10.59	5.25	0.25	1.42	6.92	7.92	1.00	0.08	9.00
2.	31 days with T.C.N.B.	19.11.59	6.17	0.42	1.66	8.25	9.00	1.25	0.00	10.25
3.	31 days at 40°F	"	6.83	1.83	1.92	10.58	9.00	1.25	0.08	10.33
4.	57 days with T.C.N.B.	15.12.59	9.26	0.67	1.82	11.75	9.00	1.42	0.17	10.58
5.	57 days at 40°F	"	7.41	2.67	1.00	11.08	6.42	2.17	0.08	8.67
6.	85 days with T.C.N.B.	12. 1.60	9.17	3.08	1.08	13.33	8.16	1.42	0.0	9.58
7.	85 days at 40°F	"	9.08	2.92	0.67	12.75	12.75	1.08	0.0	13.83
8.	113 days with T.C.N.B.	9. 2.60	14.17	3.25	0.08	17.50	13.67	0.08	0.0	13.75
9.	113 days at 40°F	"	10.34	4.08	0.25	14.67	13.42	0.58	0.0	14.00
10.	141 days with T.C.N.B.	8. 3.60	20.67	3.00	0.50	24.17	13.20	0.30	0.0	13.50
11.	141 days at 40°F	"	10.50	3.75	0.50	14.75	12.83	0.25	0.0	13.08
12.	141 days without T.C.N.B. and then desprouted and sprouted in light	8. 3.60	6.59	2.83	0.83	10.25	10.84	0.33	0.0	11.17

APPENDIX 11

LENGTH OF LONGEST SPROUT AND THEIR RATE OF GROWTH DURING SPROUTING IN LIGHT

Tr. No.	Storage Period from 19th October and Storage Treatment	Date of Sprouting	Arran Pilot								
			19.11.59			15.12.59			12. 1.60		
			L.L.S.[1]	N.L.L.[2]	R.I.[3]	L.L.S.	N.L.L.	R.I.	L.L.S.	N.L.L.	R.I.
1.	Sprouted throughout in light	22.10.59	2.50	0.9163	3.27	9.67	2.2690	5.20	18.75	2.9312	2.37
2.	31 days with T.C.N.B.	19.11.59	0	0	0	6.17	1.8197	7.00	15.00	2.7081	3.17
3.	31 days at 40°F	"	0	0	0	10.00	2.3026	8.86	16.92	2.8285	1.88
4.	57 days with T.C.N.B.	15.12.59				1.25	0.2231	-	9.42	2.2428	7.21
5.	57 days at 40°F	"				1.17	0.1570	-	10.67	2.3676	7.90
6.	85 days with T.C.N.B.	12. 1.60							1.14	0.1310	-
7.	85 days at 40°F	"							1.63	0.4886	-
8.	113 days with T.C.N.B.	9. 2.60									
9.	113 days at 40°F	"									
10.	141 days with T.C.N.B.	8. 3.60									
11.	141 days at 40°F	"									
12.	141 days without T.C.N.B. and then desprouted and sprouted in light	8. 3.60									

N.B. 1 = Length of longest sprout in mm.
2 = Napierian Logarithm of length.
3 = Relative Increment % per day.

Arran Pilot									Majestic																	
9.2.60			8.3.60			17.4.60			19.11.59			15.12.59			12.1.60			9.2.60			8.3.60			17.4.60		
L.L.S.	N.L.L.	R.I.	L.L.S.	N.L.L.	R.I.	L.L.S.	N.L.L.	R.I.	L.L.S.	N.L.L.	R.I.	L.L.S.	N.L.L.	R.I.	L.L.S.	N.L.L.	R.I.	L.L.S.	N.L.L.	R.I.	L.L.S.	N.L.L.	R.I.	L.L.S.	N.L.L.	R.I.
24.42	3.1954	0.94	30.58	3.4203	0.80	37.25	3.6176	0.49	0	0	0	0	0	0	1.67	0.5128	1.83	7.50	2.0149	1.79	9.83	2.2854	0.96	16.83	2.8232	1.34
21.42	3.0643	1.27	24.58	3.2020	0.49	31.67	3.4554	0.63	0	0	0	0	0	0	2.44	0.8920	3.18	7.83	2.0580	4.16	9.25	2.2246	0.59	15.00	2.7081	1.21
22.58	3.1171	1.03	25.42	3.2356	0.42	35.50	3.5695	0.84	0	0	0	2.0	0.6931	2.66	7.92	2.0694	4.91	9.50	2.2513	0.64	10.58	2.3590	0.38	17.33	2.8524	1.76
22.83	3.1281	3.16	23.75	3.1676	0.14	29.83	3.3955	0.57				0	0	0	1.13	0.1222	0.43	8.42	2.1306	7.17	10.00	2.3026	0.61	17.83	2.8809	1.44
14.92	2.7028	1.20	17.17	2.8431	0.50	26.00	3.2581	1.03				0	0	0	5.17	1.6429	5.87	8.08	2.0894	1.59	9.17	2.2159	0.45	16.33	2.7930	1.44
8.08	2.0894	6.99	16.25	2.7880	2.49	25.08	3.2220	1.08							0	0	0	3.17	1.1537	4.12	7.58	2.0255	3.11	12.92	2.5588	1.28
10.17	2.3192	6.53	13.00	2.5650	0.87	21.42	3.0643	1.25							0	0	0	7.17	1.9699	7.03	7.50	2.0149	0.12	13.25	2.5839	1.42
1.0	0.0000	-	8.58	2.1494	7.67	17.00	2.8332	1.71										0	0	0	3.50	1.2528	4.47	8.50	2.1401	2.21
1.42	0.3507	-	10.00	2.3026	6.97	19.83	2.9872	1.71										0	0	0	4.00	1.3863	4.95	10.17	2.3182	2.42
			1.17	0.1570	-	19.91	2.9912	7.08													0	0	0	9.33	2.2332	5.58
			4.08	1.4061	-	19.83	2.9872	3.95													1.0	0.0000	-	9.33	2.2332	5.58
						22.58	3.1171	7.79													Visible Sprout			9.83	2.2854	5.71

APPENDIX 12

EFFECT OF VARYING PERIODS OF LOW TEMPERATURE (40°F) STORAGE AND OF T.C.N.B. TREATMENT ON THE PERCENTAGE OF PLANT EMERGENCE AT DIFFERENT DATES AFTER PLANTING

Tr. No.	Storage Period from 19th October and Storage Treatment	Date of Sprouting	Percentage of plant emergence at different dates after planting										
			Arran Pilot						Majestic				
			15 Days	19 Days	22 Days	26 Days	29 Days	33 Days	15 Days	19 Days	22 Days	26 Days	29 Days
1.	Sprouted throughout in light	22.10.59	25.00	41.66	83.33	100.0	-	-	0	58.33	100.0	-	-
2.	31 days with T.C.N.B.	19.11.59	33.33	75.00	100.0	—	-	-	33.33	66.67	100.0	-	-
3.	31 days at 40°F	"	33.33	58.33	91.67	91.67	91.67	100.0	16.67	91.67	100.0	-	-
4.	57 days with T.C.N.B.	15.12.59	41.66	66.67	75.00	100.0	-	-	16.67	75.00	83.33	100.0	-
5.	57 days at 40°F	"	8.33	91.67	100.0	-	-	-	33.33	100.0	-	-	-
6.	85 days with T.C.N.B.	12. 1.60	25.0	58.33	91.67	100.0	-	-	25.00	66.67	91.67	100.0	-
7.	85 days at 40°F	"	41.66	100.00	-	-	-	-	8.33	83.33	100.00	-	-
8.	113 days with T.C.N.B.	9. 2.60	16.66	75.00	91.67	100.0	-	-	8.33	50.00	91.67	100.0	-
9.	113 days at 40°F	"	41.66	58.33	75.00	91.67	100.0	-	0	66.67	91.67	100.0	-
10.	141 days with T.C.N.B.	8. 3.60	8.33	25.00	75.00	83.33	100.0	-	0	50.00	75.00	100.0	-
11.	141 days at 40°F	"	8.33	25.00	75.00	91.67	100.0	-	8.33	50.00	83.33	100.0	-
12.	141 days without T.C.N.B. and then desprouted and sprouted in light	8. 3.60	8.33	66.67	91.67	91.67	100.0	-	0	25.00	83.33	91.67	100.0

APPENDIX 13

EFFECT OF VARYING PERIODS OF LOW TEMPERATURE (40°F) STORAGE AND OF T.C.N.B. TREATMENT ON THE "GERMINATION RATE INDEX"

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. Replication	3	0.0737	0.0245	4.15
2. Variety	1	0.0000	0.0000	-
Error 'a'	3	0.0177	0.0059	
3. Treatment	11	0.3144	0.0285	2.52 *
(a) Treatment 1 vs Treatments 2-12	1	0.0052	0.0052	-
(b) Treatment 12 vs Treatments 2-11	1	0.0407	0.0407	3.60
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	0.0099	0.0099	-
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	0.2323	0.0580	5.13 **
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.CN.B.)	4	0.0263	0.0065	-
4. Treatment x Variety	11	0.0726	0.0066	-
(a) Treatment 1 vs Treatments 2-12	1	0.0003	0.0003	-
(b) Treatment 12 vs Treatments 2-11	1	0.0203	0.0203	3.07
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	0.0025	0.0025	-
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	0.0287	0.0072	1.09
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	0.0208	0.0052	-
Error 'b'	66	0.7466	0.0133	
Total	95	1.2250		

** Significant at 1%   * Significant at 5%

APPENDIX 14

"GERMINATION RATE INDEX" FOR CONTINUOUS AND DELAYED SPROUTING TREATMENTS

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted throughout in light (Tr. 1)	0.750	0.764	0.757
Delayed Sprouting (Tr. 2-12)	0.784	0.783	0.783
Difference	- .034	- .019	- .026
	±0.057		±0.040

APPENDIX 15

"GERMINATION RATE INDEX" FOR DESPROUTING AND FOR DELAYED SPROUTING TREATMENTS

Storage Treatment	Arran Pilot	Majestic	Mean
Desprouted at the time of sprouting in light on 8.3.60 (Tr. 12)	0.764	0.667	0.715
Sprouted in light at intervals of four weeks from 19.11.59 to 8.3.60 without desprouting (Tr. 2-11)	0.786	0.794	0.790
Difference	- .022	-0.127	-0.075
	±0.060		±0.042

APPENDIX 16

"GERMINATION RATE INDEX" FOR TUBERS STORED AT 40°F AND WITH T.C.N.B. FOR VARYING PERIODS BEFORE SPROUTING

Period of Storage Before Sprouting in Light	With T.C.N.B.	At 40°F i.e. No T.C.N.B.	Mean
1. 31 days i.e. sprouted on 19.11.59	0.840	0.812	0.826
2. 57 days i.e. sprouted on 15.12.59	0.798	0.861	0.830
3. 85 days i.e. sprouted on 12.1.60	0.799	0.861	0.830
4. 113 days i.e. sprouted on 9.2.60	0.778	0.771	0.774
5. 141 days i.e. sprouted on 8.3.60	0.680	0.701	0.691
Mean	0.779	0.801	

1. S.E. of Treatment with T.C.N.B. and no T.C.N.B. ± 0.018.
2. S.E. of Time of Sprouting ± 0.028.
3. S.E. of Time of Sprouting x Treatment with or without T.C.N.B. ± 0.040.

APPENDIX 17

VARIETAL DIFFERENCES IN "GERMINATION RATE INDEX"

Period of storage before sprouting in light	Arran Pilot			Majestic		
	With T.C.N.B.	At $40^{\circ}F$ i.e. no T.C.N.B.	Mean	With T.C.N.B.	At $40^{\circ}F$ i.e. no T.C.N.B.	Mean
1. 31 days i.e. sprouted on 19.11.59	0.847	0.778	0.812	0.833	0.847	0.840
2. 57 days i.e. sprouted on 15.12.59	0.805	0.833	0.819	0.791	0.889	0.840
3. 85 days i.e. sprouted on 12.1.60	0.792	0.903	0.847	0.805	0.819	0.812
4. 113 days i.e. sprouted on 9.2.60	0.806	0.778	0.792	0.750	0.764	0.757
5. 141 days i.e. sprouted on 8.3.60	0.653	0.667	0.660	0.708	0.736	0.722
Mean	0.781	0.792		0.777	0.811	

S.E. of Variety x Treatment with or without T.C.N.B. ±0.025
S.E. of Variety x Time of sprouting ±0.04
S.E. of Variety x Time of sprouting x Treatment with or without T.C.N.B. ±0.057

EXPERIMENT 2 - APPENDIX 18 to 27

APPENDIX 18

EFFECT OF VARYING PERIODS OF LOW TEMPERATURE (40°F) AND OF T.C.N.B. TREATMENT ON THE NUMBER OF SPROUTS PER TUBER AT THE END OF SPROUTING PERIOD IN DARKNESS (23rd APRIL)

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. Variety	1	924.500	924.50	56.13 **
2. Treatment	11	2588.236	235.294	14.28 **
(a) Treatment 1 vs Treatments 2-12	2	888.783	888.788	53.967**
(b) Treatment 12 vs Treatments 2-11	1	261.578	261.578	15.883**
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	585.937	585.937	35.578**
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	624.808	156.202	9 .484**
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	227.125	56 .781	3.447**
3. Treatment x Variety	11	1367.917	124.356	7.55 **
(a) Treatment 1 vs Treatments 2-12	1	580.410	580.410	35.242**
(b) Treatment 12 vs Treatments 2-11	1	341.135	341.135	20.714**
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	92.503	92.503	5.617 *
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	189.059	47.265	2.87 *
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	164.808	41.202	2.502 *
Error	264	4348.000	16.469	
Total	287	9228.653		

** Significant at 1% * Significant at 5%

APPENDIX 19

EFFECT OF VARYING PERIODS OF LOW TEMPERATURE (40°F) STORAGE AND OF T.C.N.B. TREATMENT ON THE NUMBER OF SPROUTED EYES PER TUBER AT THE END OF SPROUTING PERIOD IN DARKNESS (23rd APRIL)

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. Variety	1	17.014	17.014	6.78 **
2. Treatment	11	163.986	14.907	5.94 **
(a) Treatment 1 vs Treatments 2-12	1	131.728	131.728	52.48 **
(b) Treatment 12 vs Treatments 2-11	1	0.238	0.238	-
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	2.604	2.604	1.04
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	17.083	4.270	1.70
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	12.333	3.083	1.22
3. Treatment x Variety	11	140.653	12.786	5.09 **
(a) Treatment 1 vs Treatments 2-12	1	61.668	61.668	24.57 **
(b) Treatment 12 vs Treatments 2-11	1	3.863	3.863	1.54
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	11.705	11.705	4.66 **
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	18.101	4.525	1.80
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	45.316	11.329	4.51 **
Error	264	662.667	2.510	
Total	287	984.320		

** Significant at 1%

APPENDIX 20

NUMBER OF SPROUTED EYES PER TUBER AT THE END OF THE SPROUTING PERIOD IN DARKNESS FOR CONTINUOUS AND DELAYED SPROUTING TREATMENTS

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted throughout in darkness (Tr. 1)	4.17	6.75	5.46
Delayed sprouting (Tr. 2-12)	8.28	7.52	7.90
Difference	-4.11	-0.77	-2.44
	±0.47		±0.33

APPENDIX 21

EFFECT OF VARYING PERIODS OF LOW TEMPERATURE (40°F) STORAGE AND OF T.C.N.B. TREATMENT ON THE NUMBER OF SPROUTS PER EYE AT THE END OF SPROUTING PERIOD IN DARKNESS (23rd APRIL)

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. Variety	1	7.286	7.286	62.27 **
2. Treatment	11	23.969	2.179	18.62 **
(a) Treatment 1 vs Treatments 2-12	1	3.457	3.457	29.55 **
(b) Treatment 12 vs Treatments 2-11	1	4.230	4.230	36.15 **
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	7.349	7.349	63.81 **
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	5.357	1.339	11.44 **
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	3.576	0.894	7.64 **
3. Treatment x Variety	11	12.931	1.175	10.04 **
(a) Treatment 1 vs Treatments 2-12	1	3.682	3.682	31.47 **
(b) Treatment 12 vs Treatments 2-11	1	3.409	3.409	29.05 **
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	3.216	3.216	28.34 **
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	0.917	0.229	1.96
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	1.707	0.427	3.65 **
Error	264	31.036	0.117	
Total	287	75.222		

** Significant at 1%

APPENDIX 22

EFFECT OF VARYING PERIODS OF LOW TEMPERATURE (40°F) STORAGE AND OF T.C.N.B. TREATMENT ON SPROUT WEIGHT AS PERCENTAGE OF FINAL WEIGHT OF POTATO AT THE END OF THE SPROUTING PERIOD IN DARKNESS (23rd APRIL)

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. Variety	1	23467.889	23467.889	473.51 **
2. Treatment	11	39611.483	3601.043	72.66 **
(a) Treatment 1 vs Treatments 2-12	1	3294.193	3294.193	66.47 **
(b) Treatment 12 vs Treatments 2-11	1	3227.152	3227.152	65.11 **
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	555.135	555.135	11.20 **
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	31360.078	7840.019	158.19 **
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	1174.924	293.731	5.93 **
3. Treatment x Variety	11	6538.305	594.391	11.99 **
(a) Treatment 1 vs Treatments 2-12	1	1495.450	1495.450	30.17 **
(b) Treatment 12 vs Treatments 2-11	1	120.608	120.608	2.43
(c) T.C.N.B. vs 40°F (No T.C.N.B.	1	186.006	186.006	3.75
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	4669.932	1167.483	23.56 **
(e) Time of sprouting x Treatment with T.C.N.B. and 40°f (No T.C.N.B.)	4	66.309	16.577	-
Error	264	13084.271	49.561	
Total	287	82701.948		

** Significant at 1%

APPENDIX 23

EFFECT OF VARYING PERIODS OF SPROUTING IN DARKNESS AND DESPROUTING AT THE TIME OF PLANTING ON THE PERCENTAGE OF PLANT EMERGENCE AT DIFFERENT DATES AFTER PLANTING

Tr. No.	Storage Period from 19th October and Storage Treatment	Date of Sprouting	Percentage of plant emergence at different dates after planting														
			Arran Pilot								Majestic						
			15 Days	19 Days	22 Days	26 Days	29 Days	33 Days	36 Days	43 Days	15 Days	19 Days	22 Days	26 Days	29 Days	33 Days	36 Days
1.	Sprouted throughout in darkness	22.10.59	0	0	8.33	41.67	66.67	66.67	66.67	75.00	0	0	33.33	100.00			
2.	31 days with T.C.N.B.	19.11.59	0	0	0	8.33	33.33	50.00	50.00	58.33	0	0	25.00	66.67	91.67	100.00	
3.	31 days at 40°F	"	0	0	8.33	25.00	41.67	41.67	50.00	58.33	0	0	8.33	58.33	75.00	91.67	100.00
4.	57 days with T.C.N.B.	15.12.59	0	16.67	25.00	66.67	75.00	91.67	91.67	91.67	0	0	66.67	91.67	100.00		
5.	57 days at 40°F	"	0	0	0	8.33	25.00	41.67	41.67	53.33	0	0	8.33	58.33	100.00		
6.	85 days with T.C.N.B.	12. 1.60	0	8.33	50.00	83.33	100.00				16.67	16.67	91.67	100.00			
7.	85 days at 40°F	"	0	0	16.67	66.67	91.67	100.00			0	0	25.00	83.33	100.00		
8.	113 days with T.C.N.B.	9. 2.60	8.33	33.33	83.33	100.00					0	8.33	75.00	83.33	100.00		
9.	113 days at 40°F	"	0	8.33	16.67	75.00	91.67	100.00			0	0	25.00	91.67	100.00		
10.	141 days with T.C.N.B.	8. 3.60	16.67	33.33	75.00	83.33	91.67	100.00			8.33	8.33	75.00	91.67	100.0		
11.	141 days at 40°F	"	0	8.33	25.00	91.67	100.00				0	8.3	66.67	83.33	100.0		
12.	141 days without T.C.N.B. and then desprouted and sprouted in darkness	8. 3.60	0	16.67	33.33	66.67	100.0				8.33	16.67	58.33	91.67	100.0		

APPENDIX 24

EFFECT OF VARYING PERIODS OF SPROUTING IN DARKNESS AFTER STORAGE AT 40°F AND OF T.C.N.B. TREATMENT, AND DESPROUTING AT THE TIME OF PLANTING ON THE "GERMINATION RATE INDEX"

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. Replication	3	0.0036	0.0012	-
2. Variety	1	0.0952	0.0952	14.209 *
Error 'a'	3	0.0203	0.0067	
3. Treatment	11	0.5578	0.0507	4.970 **
(a) Treatment 1 vs Treatments 2-12	1	0.0164	0.0164	1.608
(b) Treatment 12 vs Treatments 2-11	1	0.0147	0.0147	1.441
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	0.1371	0.1371	13.441 **
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	0.3354	0.0838	8.220 **
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	0.0542	0.0135	1.328
4. Treatment x Variety	11	0.1090	0.0099	-
(a) Treatment 1 vs Treatments 2-12	1	0.0159	0.0159	1.559
(b) Treatment 12 vs Treatments 2-11	1	0.0000	0.000	-
(c) T.C.N.B. vs 40°F (No T.C.N.B.)	1	0.0017	0.0017	-
(d) Time of sprouting from T.C.N.B. and 40°F (No T.C.N.B.)	4	0.0546	0.0136	1.333
(e) Time of sprouting x Treatment with T.C.N.B. and 40°F (No T.C.N.B.)	4	0.0368	0.0092	-
Error 'b'	66	0.6781	0.0102	
Total	95	1.4640		

** Significant at 1%   * Significant at 5%

APPENDIX 25

"GERMINATION RATE INDEX" FOR CONTINUOUS AND DELAYED SPROUTING TREATMENTS

Storage Treatment	Arran Pilot	Majestic	Mean
Sprouted throughout in darkness (Tr. 1)	0.556	0.704	0.630
Delayed Sprouting (Tr. 2-12)	0.650	0.705	0.677
Difference	-0.094	-0.001	-0.047
	±0.030		±0.021

APPENDIX 26

"GERMINATION RATE INDEX" FOR DESPROUTING BEFORE SPROUTING IN THE DARKNESS AND FOR DELAYED SPROUTING TREATMENTS WITHOUT DESPROUTING

Storage Treatment	Arran Pilot	Majestic	Mean
Desprouted before sprouting in darkness (Tr. 12)	0.686	0.750	0.718
Sprouted in darkness at intervals of four weeks from 19.11.59 to 8.3.60 without desprouting (Tr. 2-11)	0.646	0.700	0.673
Difference	+0.040	+0.050	+0.045
	±0.030		±0.021

APPENDIX 27

"GERMINATION RATE INDEX" OF ARRAN PILOT AND MAJESTIC FOUND FOR DIFFERENT PERIODS WITH OR WITHOUT T.C.N.B. BEFORE SPROUTING IN THE DARKNESS AND DESPROUTED AT THE TIME OF PLANTING.

Period of storage before sprouting in darkness	Arran Pilot			Majestic		
	With T.C.N.B.	At 40°F. i.e. no T.C.N.B.	Mean	With T.C.N.B.	At 40°F. i.e. no T.C.N.B.	Mean
31 days i.e. Sprouted on 19.11.59.	0.500	0.556	0.528	0.649	0.593	0.621
57 days i.e. Sprouted on 15.12.59.	0.662	0.454	0.558	0.732	0.630	0.681
85 days i.e. Sprouted on 12.1.60.	0.713	0.639	0.676	0.806	0.676	0.741
113 days i.e. Sprouted on 9.2.60.	0.806	0.658	0.732	0.741	0.686	0.713
141 days i.e. Sprouted on 8.3.60.	0.778	0.695	0.736	0.760	0.732	0.746
Mean.	0.691	0.600		0.738	0.665	

S.E. of Variety x Treatment with or without T.C.N.B. ± 0.0225.

S.E. of Variety x Time of sprouting ± 0.0357.

S.E. of Variety x Time of sprouting x Treatment with or without T.C.N.B. ± 0.0504.

EXPERIMENT 3 - APPENDIX 28 to 37

APPENDIX 28

EFFECT OF DESPROUTING AFTER VARYING PERIODS OF STORAGE ON THE NUMBER OF SPROUTS PER TUBER IN ARRAN PILOT AND MAJESTIC AT THE END OF THE SPROUTING PERIOD IN LIGHT AND DARKNESS (24th April)

Storage treatment commencing from 22 October.	Arran Pilot			Majestic		
	Light	Darkness	Mean	Light	Darkness	Mean
Sprouted throughout in	6.33	7.67	7.00	9.92	6.92	8.42
Apical eyes removed and sprouted throughout in	8.25	3.33	5.79	11.67	8.42	10.04
Sprouted in darkness for 123 days and then desprouted and resprouted in	12.67	11.58	12.12	11.33	9.58	10.45
Sprouted in darkness for 137 days and then desprouted and resprouted in	13.83	13.00	13.41	12.50	9.83	11.16
Mean.	10.27	8.89	9.58	11.35	8.69	10.08

S.E. of Variety ± 0.106

S.E. of Variety x Time of desprouting ± 0.67

S.E. of Variety x Light and Darkness ± 0.15

S.E. of Variety x Time of desprouting x Light and Darkness ± 0.92.

(Analysis of Variance see Appendix 29)

APPENDIX 29

EFFECT OF DESPROUTING AFTER VARYING PERIODS OF STORAGE ON THE NUMBER OF SPROUTS PER TUBER

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. Variety	1	12.00	12.00	1.10
2. Treatment	7	1082.00	154.571	14.21 **
(a) Light vs Darkness	1	208.333	208.333	19.16 **
(b) Time of desprouting	3	803.500	267.833	24.63 **
(c) Time of desprouting x Light and Darkness	3	70.167	23.389	2.150
3. Treatment x Variety	7	392.500	56.071	5.15 **
(a) Light vs Darkness	1	24.084	24.084	2.21
(b) Time of desprouting	3	313.667	104.556	9.61 **
(c) Time of desprouting x Light and Darkness	3	54.749	18.250	1.68
Error	176	1914.167	10.875	
Total	191	3400.667		

** Significant at 1%

APPENDIX 30

EFFECT OF DESPROUTING AFTER VARYING PERIODS OF STORAGE ON THE NUMBER OF SPROUTED EYES PER TUBER IN ARRAN PILOT AND MAJESTIC AT THE END OF THE SPROUTING PERIOD IN LIGHT AND DARKNESS (24TH APRIL)

Treatment	Arran Pilot			Majestic		
	Light	Darkness	Mean	Light	Darkness	Mean
Sprouted throughout in	5.67	6.17	5.92	7.50	5.58	6.54
Apical eyes removed and sprouted throughout in	6.83	3.17	5.00	7.50	5.67	6.58
Sprouted in darkness for 123 days and then desprouted and resprouted in	8.50	8.17	8.33	7.17	6.33	6.75
Sprouted in darkness for 137 days and then desprouted and resprouted in	8.33	8.42	8.37	7.58	6.67	7.12
Mean	7.33	6.48	6.90	7.43	6.06	6.75

S.E. of Variety ± 0.196
S.E. of Variety x Time of desprouting ±0.39
S.E. of Variety x Light and darkness ± 0.278
S.E. of Variety x Time of desprouting x Light and darkness ±0.559

APPENDIX 31

EFFECT OF DESPROUTING AFTER VARYING PERIODS OF STORAGE ON THE NUMBER OF SPROUTED EYES PER TUBER

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. Variety	1	1.172	1.172	-
2. Treatment	7	236.954	33.850	9.12 **
(a) Light vs Darkness	1	59.631	59.631	10.06 **
(b) Time of desprouting	3	134.016	44.672	12.03 **
(c) Time of desprouting x Light and Darkness	3	43.307	14.436	3.89 **
3. Treatment x Variety	7	113.786	16.255	4.38 **
(a) Light vs Darkness	1	3.255	3.255	-
(b) Time of desprouting	3	82.433	27.478	7.40 **
(c) Time of desprouting x Light and Darkness	3	28.098	9.366	2.52
Error	176	653.417	3.712	
Total	191	1005.329		

** Significant at 1%

APPENDIX 32

EFFECT OF DESPROUTING AFTER VARYING PERIODS OF STORAGE ON THE NUMBER OF SPROUTS PER EYE IN ARRAN PILOT AND MAJESTIC AT THE END OF THE SPROUTING PERIOD IN LIGHT AND DARKNESS (24TH APRIL)

Storage Treatment Commencing from 22nd October	Arran Pilot			Majestic		
	Light	Darkness	Mean	Light	Darkness	Mean
Sprouted throughout in	1.15	1.21	1.18	1.29	1.20	1.24
Apical eyes removed and sprouted throughout in	1.26	1.06	1.16	1.55	1.48	1.51
Sprouted in darkness for 123 days and then desprouted and resprouted in	1.48	1.45	1.46	1.63	1.53	1.58
Sprouted in darkness for 137 days and then desprouted and resprouted in	1.67	1.56	1.61	1.68	1.50	1.59
Mean	1.39	1.32	1.35	1.53	1.43	

S.E. of Variety $\pm$0.03
S.E. of Variety x Time of desprouting $\pm$0.06
S.E. of Variety x Light and darkness $\pm$0.04
S.E. of Variety x Time of desprouting x Light and darkness $\pm$0.08

APPENDIX 33

EFFECT OF DESPROUTING ON THE NUMBER OF SPROUTS PER EYE

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. Variety	1	0.761	0.761	8.75 **
2. Treatment	7	4.999	0.714	8.21 **
(a) Light vs Darkness	1	0.377	0.377	4.33 *
(b) Time of desprouting	3	4.490	1.477	16.98 **
(c) Time of desprouting x Light and Darkness	3	0.132	0.044	0.50
3. Treatment x Variety	7	1.103	0.157	1.80
(a) Light vs Darkness	1	0.018	0.018	-
(b) Time of desprouting	3	0.940	0.313	1.99
(c) Time of desprouting x Light and Darkness	3	0.145	0.048	-
Error	176	15.326	0.087	
Total	191	22.189		

** Significant at 1% * Significant at 5%

APPENDIX 34

EFFECT OF DESPROUTING AFTER VARYING PERIODS OF STORAGE AND RESPROUTING IN LIGHT AND DARKNESS ON PERCENTAGE OF PLANT EMERGENCE AT DIFFERENT DATES AFTER PLANTING

Percentage of plant emergence at different dates after planting

Tr. No.	Storage Treatment from 22nd October	Arran Pilot 12 Days	15 Days	19 Days	22 Days	26 Days	29 Days	33 Days	36 Days	40 Days
1.	Sprouted throughout in light	25.00	50.00	66.67	83.33	100.0				
2.	Sprouted throughout in darkness	0	8.33	25.00	58.33	83.33	91.67	100.00		
3.	Apical eyes removed and sprouted throughout in light	8.33	58.33	83.33	91.67	91.67	91.67	100.00		
4.	Apical eyes removed and sprouted throughout in darkness	0	16.67	50.00	58.33	83.33	91.67	91.67	91.67	100.00
5.	Sprouted in darkness for 123 days and then desprouted and resprouted in light	25.00	33.33	41.67	66.67	83.33	91.67	100.00		
6.	Sprouted in darkness for 123 days and then desprouted and resprouted in darkness	0	25.00	91.67	91.67	91.67	91.67	100.00		
7.	Sprouted in darkness for 137 days and then desprouted and resprouted in light	8.33	16.67	33.33	41.67	83.33	100.00			
8.	Sprouted in darkness for 137 days and then desprouted and resprouted in darkness	25.00	75.00	83.33	91.67	91.67	100.00			
9.	Sprouted throughout the storage period in darkness and desprouted before planting	0	0	0	0	16.67	41.67	41.67	50.00	75.00

Tr. No.	Storage Treatment from 22nd October	Majestic 12 Days	15 Days	19 Days	22 Days	26 Days	29 Days	33 Days	36 Days	40 Days
1.	Sprouted throughout in light	0	50.00	83.33	100.00					
2.	Sprouted throughout in darkness	0	25.00	25.00	66.67	91.67	91.67	100.00		
3.	Apical eyes removed and sprouted throughout in light	0	41.67	91.67	100.00					
4.	Apical eyes removed and sprouted throughout in darkness	8.33	41.67	75.00	91.67	91.67	91.67	91.67	91.67	100.00
5.	Sprouted in darkness for 123 days and then desprouted and resprouted in light	0	8.33	75.00	91.67	100.00				
6.	Sprouted in darkness for 123 days and then desprouted and resprouted in darkness	0	16.67	41.67	66.67	91.67	100.00			
7.	Sprouted in darkness for 137 days and then desprouted and resprouted in light	0	25.00	91.67	100.00					
8.	Sprouted in darkness for 137 days and then desprouted and resprouted in darkness	8.33	50.00	50.00	100.00					
9.	Sprouted throughout the storage period in darkness and desprouted before planting	0	0	0	8.33	58.33	100.00			

APPENDIX 35

EFFECT OF DESPROUTING ON THE "GERMINATION RATE INDEX"

Tr. No.	Storage treatment commencing from 22 October.	"Germination Rate Index"		
		Arran Pilot	Majestic	Mean
1.	Sprouted throughout in Light	0.806	0.815	0.810
2.	" " " Darkness	0.630	0.667	0.648
3.	Apical eyes removed and sprouted throughout in Light	0.806	0.815	0.810
4.	" " " " " " Darkness	0.648	0.760	0.704
5.	Sprouted in darkness for 123 days and then desprouted and resprouted in Light	0.713	0.750	0.731
6.	Sprouted in darkness for 123 days and then desprouted and resprouted in Darkness	0.769	0.686	0.727
7.	Sprouted in darkness for 137 days and then desprouted and resprouted in Light	0.648	0.797	0.722
8.	Sprouted in darkness for 137 days and then desprouted and resprouted in Darkness	0.852	0.824	0.838
9.	Sprouted throughout in darkness and desprouted at the time of planting	0.342	0.519	0.430
	Mean.	0.690	0.737	

S.E. of Variety ± 0.013

S.E. of Treatment ± 0.037

S.E. of Treatment x Variety ± 0.053

APPENDIX 36

EFFECT OF DESPROUTING ON THE "GERMINATION RATE INDEX"

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
1. Replication	3	0.0226	0.0075	1.21
2. Variety	1	0.0387	0.0387	6.24
Error 'a'	3	0.0188	0.0062	
3. Treatment	8	0.9550	0.1193	10.46 **
(a) Planting with sprouts vs without sprouts	1	0.7223	0.7223	63.36 **
(b) Light vs Darkness	1	0.0247	0.0247	2.17
(c) Time of desprouting	3	0.0239	0.0096	-
(d) Time of desprouting x Light and Darkness	3	0.1791	0.0597	5.24 **
4. Treatment x Variety	8	0.1134	0.0141	1.24
(a) Planting with sprouts vs without sprouts	1	0.0379	0.0379	3.32
(b) Light vs Darkness	1	0.0069	0.0069	-
(c) Time of desprouting	3	0.0188	0.0063	-
(d) Time of desprouting x Light and Darkness	3	0.0498	0.0166	1.46
Error 'b'	48	0.5484	0.0114	
Total	71	1.6969		

** Significant at 1%

APPENDIX 37

EFFECT OF DESPROUTING AFTER VARYING PERIODS OF STORAGE AND RESPROUTING IN LIGHT AND DARKNESS ON THE "GERMINATION RATE INDEX" OF ARRAN PILOT AND MAJESTIC

Storage treatment commencing from 22nd October	Arran Pilot			Majestic			Mean
	Light	Darkness	Mean	Light	Darkness	Mean	
Sprouted throughout in	0.806	0.630	0.718	0.815	0.667	0.741	0.729
Apical eyes removed and sprouted throughout in	0.806	0.648	0.727	0.815	0.760	0.787	0.757
Sprouted in darkness for 123 days and then desprouted and resprouted in	0.713	0.769	0.741	0.750	0.686	0.718	0.724
Sprouted in darkness for 137 days and then desprouted and resprouted in	0.648	0.852	0.750	0.797	0.824	0.810	0.780
Mean	0.743	0.725		0.794	0.744		

S.E. of Time of desprouting ±0.0267
S.E. of Variety x Time of desprouting ±0.0377
S.E. of Variety x Light and darkness ±0.0267
S.E. of Variety x Time of desprouting x Light and darkness ±0.053

EXPERIMENT 4 - APPENDIX 38 to 87

APPENDIX 38

MEAN MONTHLY TEMPERATURES OF THE HIGH AND MEDIUM TEMPERATURE STORAGE ROOMS AND OF THE FARM BUILDING (LOW TEMPERATURE)

Month	High		Medium		Low	
	Minimum °F	Maximum °F	Minimum °F	Maximum °F	Minimum °F	Maximum °F
November	67.0	71.4	57.6	60.7	42.0	45.2
December	65.0	72.0	52.4	59.4	38.5	41.5
January	69.7	75.0	50.0	57.1	35.7	40.7
February	67.0	76.5	50.5	57.2	37.7	43.3
March	70.4	77.3	52.7	58.5	44.0	49.6
April	74.0	80.0	53.7	59.3	43.8	49.7

APPENDIX 39

INITIAL FRESH WEIGHT (GM.) OF TUBERS: AND THE FRESH WEIGHT OF TUBER AND SPROUTS AT THE TIMES OF DESPROUTING

Storage Treatment	Arran Pilot					
	d_1					
	Initial wt. (gm.) of tuber		Wt. (gm.) of tuber at the time of desprout		Wt. (gm.) of sprout at the time of desprout	
	S_1	S_2	S_1	S_2	S_1	S_2
Stored at 65^{o}-80^{o}F without T.C.N.B.	9209.0	5718.0	8426.0	5211.0	126.5	94.9
Stored at 50^{o}-60^{o}F without T.C.N.B.	9109.0	5966.0	8328.0	5347.0	254.9	184.2
Stored at 40^{o}F without T.C.N.B.	9107.0	5822.0	8892.0	5663.0	-	-
Stored at 65^{o}-80^{o}F with T.C.N.B.	8334.0	5440.0	7654.0	4934.0	96.5	53.6
Stored at 50^{o}-60^{o}F with T.C.N.B.	8887.0	5673.0	8354.0	5255.0	55.1	35.0
Stored at 40^{o}F with T.C.N.B.	9633.0	5886.0	9409.0	5783.0	-	-

d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 - Desprouted at the time of planting

S_1 = Large Seed
S_2 = Small Seed

Arran Pilot											
d_2						d_3					
Initial wt. (gm.) of tuber		Wt. (gm.) of tuber at the time of desprout		Wt. (gm.) of sprout at the time of desprout		Initial wt. (gm.) of tuber		Wt. (gm.) of tuber at the time of desprout		Wt. (gm.) of sprout at the time of desprout	
S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
9400.0	5786.0	7068.0	4321.0	949,7	618.8	9214.0	5829.0	4714.0	2842.0	1374.6	1067.8
9300.0	5948.0	7168.0	4457.0	1017.9	685.0	8712.0	5274.0	4698.0	2734.0	1885.8	1176.8
9210.0	6092.0	8781.0	5818.0	-	-	9152.0	5790.0	8516.0	5449.0	5.85	5.00
9472.0	5621.0	7226.0	4247.0	627.9	295.5	9575.0	5352.0	4851.0	2541.0	1283.7	727.6
8907.0	5926.0	7310.0	4891.0	327.8	175.5	8683.0	5429.0	6142.0	3672.0	545.3	328.0
9135.0	6018.0	8836.0	5761.0	-	-	9328.0	5873.0	8845.0	5566.0	-	-

Majestic											
d_1						d_2					
Initial wt. (gm.) of tuber		Wt. (gm.) of tuber at the time of desprout		Wt. (gm.) of sprout at the time of desprout		Initial wt. (gm.) of tuber		Wt. (gm.) of tuber at the time of desprout		Wt. (gm.) of sprout at the time of desprout	
S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
9906.0	6267.0	9267.0	5855.0	33.0	22.83	9518.0	6488.0	8067.0	5403.0	292.0	228.3
9206.0	6347.0	8622.0	5965.0	11.20	10.2	9755.0	5993.0	8641.0	5245.0	278.5	149.9
9584.0	6161.0	9305.0	5990.0	-	-	9905.0	6467.0	9460.0	6187.0	-	-
10183.0	6919.0	9538.0	6477.0	20.60	16.3	9556.0	6331.0	8237.0	5554.0	157.2	89.0
9393.0	6417.0	8905.0	6063.0	-	-	9636.0	6414.0	8892.0	5870.0	-	-
9760.0	6133.0	9455.0	5905.0	-	-	9532.0	6303.0	9166.0	6055.0	-	-

Majestic					
d_3					
Initial wt. (gm.) of tuber		Wt. (gm.) of tuber at the time of desprout		Wt. (gm.) of sprout at the time of desprout	
S_1	S_2	S_1	S_2	S_1	S_2
9125.0	6250.0	6556.0	4444.0	537.8	359.9
9989.0	6797.0	7595.0	5048.0	897.0	701.5
9565.0	6340.0	8918.0	5925.0	-	-
9355.0	6430.0	7072.0	4867.0	2990.0	219.0
9710.0	6396.0	8550.0	5687.0	27.50	2.5
9208.0	6870.0	8663.0	6483.0	-	-

APPENDIX 40

METEREOLOGICAL OBSERVATIONS 1961

Month	Temperature °F			Rainfall (inches)		Sunshine Hours
	Minimum	Maximum	Difference from Average	Total Inches	Difference from Average	
April	39.4	51.0	+2.4	2.36	+0.57	83.9
May	41.6	55.7	+1.3	1.22	-1.30	152.7
June	46.4	60.1	+0.7	1.16	-0.99	125.9
July	48.3	61.2	-1.6	3.07	+0.07	125.6
August	48.6	62.2	+0.1	4.10	+0.52	147.1
September	48.1	61.8	+2.8	2.48	-1.08	103.1

APPENDIX 41

EFFECT OF DIFFERENT STORAGE TREATMENTS ON THE SHRINKAGE OF SEED TUBERS AT THE TIMES OF DESPROUTING

Storage Treatment	Arran Pilot																	
	d_1									d_2								
	Loss in wt. (gm.) due to Sprout		Loss in wt. (gm.) due to Transpiration and Respiration		Total loss in wt. (gm.)		Mean			Loss in wt. (gm.) due to Sprout		Loss in wt. (gm.) due to Transpiration and Respiration		Total loss in wt. (gm.)		Mean		
	S_1	S_2	S_1	S_2	S_1	S_2	Loss in wt. (gm.) due to Sprout	Loss in wt. (gm.) due to Transpiration and Respiration	Total loss in wt. (gm.)	S_1	S_2	S_1	S_2	S_1	S_2	Loss in wt. (gm.) due to Sprout	Loss in wt. (gm.) due to Transpiration and Respiration	Total loss in wt. (gm.)
Stored at 65°–80°F without T.C.N.B.	126.5	94.9	656.5	412.1	783.0	507.0	110.7	534.3	645.0	949.7	618.8	1382.3	846.2	2332.0	1465.0	784.2	1114.3	1898.5
Stored at 50°–60°F without T.C.N.B.	254.9	184.2	526.1	434.8	781.0	619.0	219.5	480.5	700.0	1017.9	685.0	1114.1	806.0	2132.0	1491.0	851.4	960.1	1811.5
Stored at 40°F without T.C.N.B.	-	-	315.0	159.0	315.0	159.0	-	237.0	237.0	-	-	429.0	274.0	429.0	274.0	-	351.5	351.5
Stored at 65°–80°F with T.C.N.B.	96.5	53.6	583.5	452.4	680.0	506.0	75.0	518.0	593.0	627.9	295.5	1618.1	1078.5	2246.0	1374.0	461.7	1348.3	1810.0
Stored at 50°–60°F with T.C.N.B.	55.1	35.0	477.9	383.0	533.0	418.0	45.0	430.5	475.5	327.8	175.5	1269.2	859.5	1597.0	1035.0	251.6	1064.4	1316.0
Stored at 40°F with T.C.N.B.	-	-	224.0	103.0	224.0	103.0	-	163.5	163.5	-	-	299.0	257.0	299.0	257.0	-	278.0	278.0
Mean	88.8	61.3	463.8	324.0	552.6	385.3				487.2	295.8	1018.6	686.9	1505.8	982.7			

d_1 = Desprouted on 4. 1.61
d_2 = " 20.2.61
d_3 = Desprouted at the time of planting.

S_1 = Large Seed
S_2 = Small Seed

Arran Pilot									Majestic								
d_3									d_1								
Loss in wt. (gm.) due to Sprout		Loss in wt. (gm.) due to Transpiration and Respiration		Total loss in wt. (gm.)		Mean			Loss in wt. (gm.) due to Sprout		Loss in wt. (gm.) due to Transpiration and Respiration		Total loss in wt. (gm.)		Mean		
S_1	S_2	S_1	S_2	S_1	S_2	Loss in wt. (gm.) due to Sprout	Loss in wt. (gm.) due to Transpiration and Respiration	Total loss in wt. (gm.)	S_1	S_2	S_1	S_2	S_1	S_2	Loss in wt. (gm.) due to Sprout	Loss in wt. (gm.) due to Transpiration and Respiration	Total loss in wt. (gm.)
1374.6	1067,8	3125.4	1919.2	4500.0	2987.0	1221.2	2522.3	3743.5	33.0	22.83	606.0	389.17	639.0	412.0	27.91	497.59	525.5
1885.8	1176.8	2128.2	1363.2	4014.0	2540.0	1531.3	1745.7	3277.0	11.20	10.2	572.8	371.8	584.0	382.0	10.70	472.3	483.0
5.85	5.00	630.15	336.0	636.0	341.0	5.42	483.08	488.5	-	-	279.0	171.0	279.0	171.0	-	225.0	225.0
1283.7	727.6	3440.3	2083.4	4724.0	2811.0	1005.6	2761.9	3767.5	20.60	16.3	624.4	425.7	645.0	442.0	18.4	525.1	543.5
545.3	328.0	1995.7	1429.0	2541.0	1757.0	436.6	1712.4	2149.0	-	-	488.0	354.0	488.0	354.0	-	421.0	421.0
-	-	483.0	307.0	483.0	307.0	-	395.0	395.0	-	-	305.0	228.0	305.0	228.0	-	266.5	266.5
849.2	550.9	1967.1	1239.6	2816.3	1790.5				10.8	8.2	479.2	323.3	490.0	331.5			

Majestic								
d_2								
Loss in wt. (gm.) due to Sprout		Loss in wt. (gm.) due to Transpiration and Respiration		Total loss in wt. (gm.)		Mean		
						Loss in wt. (gm.) due to Sprout	Loss in wt. (gm.) due to Transpiration and Respiration	Total loss in wt. (gm.)
S_1	S_2	S_1	S_2	S_1	S_2			
292.0	228.3	1159.0	856.7	1451.0	1085.0	260.1	1007.9	1268.0
278.5	149.9	835.5	598.1	1114.0	748.0	214.2	716.8	931.0
-	-	445.0	280.0	445.0	280.0	-	362.5	362.5
157.2	89.0	1161.8	688.0	1319.0	777.0	123.1	924.9	1048.0
-	-	744.0	544.0	744.0	544.0	-	644.0	644.0
-	-	366.0	248.0	366.0	248.0	-	307.0	307.0
121.3	77.9	785.2	535.8	906.5	613.7			

Majestic								
d_3								
Loss in wt. (gm.) due to Sprout		Loss in wt. (gm.) due to Transpiration and Respiration		Total loss in wt. (gm.)		Mean		
						Loss in wt. (gm.) due to Sprout	Loss in wt. (gm.) due to Transpiration and Respiration	Total loss in wt. (gm.)
S_1	S_2	S_1	S_2	S_1	S_2			
537.8	359.9	2031.2	1446.1	2569.0	1806.0	448.8	1738.7	2187.5
897.0	701.5	1497.0	1047.5	2394.0	1749.0	799.2	1272.3	2071.5
-	-	647.0	415.0	647.0	415.0	-	531.0	531.0
299.0	219.0	1984.0	1344.0	2283.0	1563.0	259.0	1664.0	1923.0
27.50	2.5	1132.5	706.5	1160.0	709.0	15.0	919.5	934.5
-	-	545.0	387.0	545.0	387.0	-	466.0	466.0
293.5	213.8	1306.1	891.0	1599.6	1104.8			

APPENDIX 42

EFFECT OF DIFFERENT STORAGE TREATMENTS ON THE SHRINKAGE OF SEED TUBERS AT THE TIMES OF DESPROUTING

Arran Pilot — d_1

Storage Treatment	Loss in wt. (%) due to Sprout S_1	Loss in wt. (%) due to Sprout S_2	Loss in wt. (%) due to Transpiration and Respiration S_1	Loss in wt. (%) due to Transpiration and Respiration S_2	Total loss in wt. (%) S_1	Total loss in wt. (%) S_2	Mean: Loss in wt. (%) due to Sprout	Mean: Loss in wt. (%) due to Transpiration and Respiration	Mean: Total loss in wt. (%)
Stored at 65°-80°F without T.C.N.B.	1.37	1.66	7.13	7.21	8.50	8.87	1.51	7.17	8.68
Stored at 50°-60°F without T.C.N.B.	2.80	3.09	5.77	7.28	8.57	10.37	2.94	6.53	9.47
Stored at 40°F without T.C.N.B.	-	-	2.36	2.73	2.36	2.73	-	2.54	2.54
Stored at 65°-80°F with T.C.N.B.	1.16	0.98	7.00	8.32	8.16	9.30	1.07	7.66	8.73
Stored at 50°-60°F with T.C.N.B.	0.62	0.62	5.38	6.75	6.0	7.37	0.62	6.06	6.68
Stored at 40°F with T.C.N.B.	-	-	2.32	1.75	2.32	1.75	-	2.03	2.03
Mean	0.99	1.06	4.99	5.67	5.98	6.73			

Arran Pilot — d_2

Storage Treatment	Loss in wt. (%) due to Sprout S_1	Loss in wt. (%) due to Sprout S_2	Loss in wt. (%) due to Transpiration and Respiration S_1	Loss in wt. (%) due to Transpiration and Respiration S_2	Total loss in wt. (%) S_1	Total loss in wt. (%) S_2	Mean: Loss in wt. (%) due to Sprout	Mean: Loss in wt. (%) due to Transpiration and Respiration	Mean: Total loss in wt. (%)
Stored at 65°-80°F without T.C.N.B.	10.10	10.69	14.71	14.63	24.81	25.32	10.39	14.67	25.06
Stored at 50°-60°F without T.C.N.B.	10.94	11.51	11.98	13.56	22.92.	25.07	11.22	12.77	23.99
Stored at 40°F without T.C.N.B.	-	-	4.66	4.50	4.66	4.50	-	4.58	4.58
Stored at 65°-80°F with T.C.N.B.	6.63	5.26	17.08	19.18	23.71	24.44	5.94	18.13	24.07
Stored at 50°-60°F with T.C.N.B.	3.68	2.96	14.25	14.50	17.93	17.46	3.32	14.37	17.69
Stored at 40°F with T.C.N.B.	-	-	3.27	4.27	3.27	4.27	-	3.77	3.77
Mean	5.22	5.07	10.99	11.77	16.21	16.84			

d_1 = Desprouted on 4.1.61
d_2 = " " 20.2.61
d_3 = Desprouted at the time of planting.

S_1 = Large Seed
S_2 = Small Seed

Arran Pilot								
d_3								
Loss in wt. (%) due to Sprout		Loss in wt. (%) due to Transpiration and Respiration		Total loss in wt. (%)		Mean		
S_1	S_2	S_1	S_2	S_1	S_2	Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt. (%)
14.92	18.32	33.92	32.92	48.84	51.24	16.62	33.42	50.04
21.65	22.31	24.42	25.85	46.07	48.16	21.98	25.13	47.11
0.06	0.08	6.86	5.81	6.92	5.89	0.07	6.33	6.40
13.41	13.59	35.93	38.93	49.34	52.52	13.50	37.43	50.93
6.28	6.04	22.98	26.32	29.26	32.36	6.16	24.65	30.81
-	-	5.18	5.23	5.18	5.23	-	5.20	5.20
9.39	10.06	21.55	22.51	30.93	32.57			

Majestic								
d_1								
Loss in wt. (%) due to Sprout		Loss in wt. (%) due to Transpiration and Respiration		Total loss in wt. (%)		Mean		
S_1	S_2	S_1	S_2	S_1	S_2	Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt. (%)
0.33	0.36	6.12	6.21	6.45	6.57	0.34	6.17	6.51
0.12	0.16	6.22	5.86	6.34	6.02	0.14	6.04	6.18
-	-	2.91	2.77	2.91	2.77	-	2.84	2.84
0.20	0.23	6.13	6.16	6.33	6.39	0.21	6.15	6.36
-	-	5.20	5.52	5.20	5.52	-	5.36	5.36
-	-	3.12	3.72	3.12	3.72	-	3.42	3.42
0.11	0.12	4.95	5.04	5.06	5.16			

Majestic								
d_2								
Loss in wt. (%) due to Sprout		Loss in wt. (%) due to Transpiration and Respiration		Total loss in wt. (%)		Mean		
						Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt. (%)
S_1	S_2	S_1	S_2	S_1	S_2			
3.07	3.52	12.17	13.20	15.24	16.72	3.29	12.69	15.98
2.85	2.50	8.57	9.98	11.42	12.48	2.67	9.28	11.95
-	-	4.49	4.33	4.49	4.33	-	4.41	4.41
1.64	1.40	12.16	10.87	13.80	12.27	1.52	11.51	13.03
-	-	7.72	8.48	7.72	8.48	-	8.10	8.10
-	-	3.84	3.93	3.84	3.93	-	3.88	3.88
1.26	1.24	8.16	8.46	9.42	9.70			

Majestic								
d_3								
Loss in wt. (%) due to Sprout		Loss in wt. (%) due to Transpiration and Respiration		Total loss in wt. (%)		Mean		
						Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt. (%)
S_1	S_2	S_1	S_2	S_1	S_2			
5.89	5.76	22.26	23.14	28.15	28.90	5.82	22.70	28.52
8.98	10.32	14.99	15.41	23.97	25.73	9.65	15.20	24.85
-	-	6.76	6.54	6.76	6.54	-	6.65	6.65
3.20	3.40	21.20	20.91	24.40	24.31	3.30	21.05	24.35
0.28	0.04	11.67	11.04	11.95	11.08	0.16	11.35	11.51
-	-	5.92	5.63	5.92	5.63	-	5.70	5.70
3.06	3.25	13.80	13.78	16.86	17.03			

APPENDIX 43

EFFECT OF DIFFERENT STORAGE TREATMENTS ON THE SUBSEQUENT GROWTH OF SPROUTS *

Storage Treatment	Arran Pilot						Majestic					
	d_1			d_2			d_1			d_2		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
Stored at 65°-80°F without T.C.N.B.	81.85	49.75	65.80	15.45	13.90	14.67	26.70	15.50	21.20	8.30	5.0	6.65
Stored at 50°-60°F without T.C.N.B.	52.75	36.05	44.40	16.35	11.10	13.72	11.20	10.10	10.65	19.0	6.80	12.90
Stored at 40°F without T.C.N.B.	23.40	22.90	23.15	11.95	9.63	10.79	9.10	4.90	7.0	5.25	3.90	4.57
Stored at 65°-80°F with T.C.N.B.	45.50	46.25	45.87	2.15	8.15	5.15	23.20	21.20	22.20	7.10	6.70	6.90
Stored at 50°-60°F with T.C.N.B.	60.70	36.80	48.75	16.62	13.60	15.11	7.30	10.30	8.80	0.90	2.30	1.60
Stored at 40°F with T.C.N.B.	29.0	27.85	28.42	12.20	10.35	11.27	7.20	4.40	5.80	6.30	4.60	5.45
Mean	48.87	36.60		12.45	11.12		14.12	11.07		7.81	4.88	

d_1 = Desprouted on 4.1.61 S_1 = Large seed
d_2 = Desprouted on 20.2.61 S_2 = Small seed

* Total wt. (gm.) of sprout of 5 tuber at the end of the sprouting period (11th April) in light.

APPENDIX 44

NUMBER OF SPROUTS PER TUBER AT THE END OF THE SPROUTING PERIOD (11th APRIL)

Date of Desprouting	Storage Treatment	Arran Pilot										Majestic									
		Size Group in mm.										Size Group in mm.									
		Large Seed					Small Seed					Large Seed					Small Seed				
		1-10	11-30	31-60	61-Over	Total no. of Sprout	1-10	11-30	31-60	61-Over	Total no. of Sprout	1-10	11-30	31-60	61-Over	Total no. of Sprout	1-10	11-30	31-60	61-Over	Total no. of Sprout
d_1 (i.e. First Desprouting on 4.1.61	Stored at 65°-80°F without T.C.N.B.	5.5	1.1	0.6	4.3	11.5	4.6	0.7	0.1	3.5	8.9	3.0	1.3	1.5	-	5.8	2.5	0.8	1.9	-	5.2
	" " 50°-60°F " "	6.6	0.9	0.1	3.0	10.6	5.3	0.8	0.3	2.4	8.8	3.3	1.7	0.4	-	5.4	3.7	1.0	0.6	-	5.3
	" " 40°F " "	7.4	1.1	1.1	1.1	10.7	8.2	0.3	0.6	1.6	10.7	8.8	1.5	0.5	-	10.8	6.0	1.5	-	-	7.5
	Stored at 65°-80°F with T.C.N.B.	6.6	1.3	0.2	4.6	12.7	4.8	0.7	0.1	4.1	9.7	3.4	2.0	2.1	0.5	8.0	3.2	2.2	1.3	0.7	7.4
	" " 50°-60°F " "	5.4	1.6	0.7	5.0	12.7	5.8	1.1	0.4	3.4	10.7	0.3	1.2	0.1	-	1.6	1.5	0.4	0.4	-	2.3
	" " 40°F " "	9.2	0.8	0.7	2.0	12.7	10.1	0.9	0.3	1.2	12.5	7.4	2.1	-	-	9.5	5.7	1.3	0.1	-	7.1
d_2 (i.e. Second Desprouting on 20.2.61	Stored at 65°-80°F without T.C.N.B.	9.6	4.2	2.3	0.3	16.4	6.0	2.8	2.4	0.2	11.4	3.2	3.0	0.5	-	6.7	2.8	2.8	0.2	-	5.8
	" " 50°-60°F " "	9.3	6.4	0.5	0.2	16.4	5.5	4.8	0.5	-	10.8	2.3	2.3	1.7	0.1	6.4	2.9	3.3	0.1	-	6.3
	" " 40°F " "	11.3	3.7	1.1	-	16.1	5.7	3.1	0.5	0.1	9.4	11.6	3.0	-	-	14.6	9.4	1.9	-	-	11.3
	Stored at 65°-80°F with T.C.N.B.	5.4	3.3	0.3	-	9.0	6.2	3.4	0.7	-	10.3	6.2	3.1	-	-	9.3	4.9	3.1	0.5	0.1	8.6
	" " 50°-60°F " "	4.7	3.7	1.3	0.4	10.1	4.0	1.7	1.8	0.4	7.9	0.2	0.3	-	-	0.5	1.3	0.2	-	-	1.5
	" " 40°F " "	13.3	4.3	0.9	-	18.5	12.7	2.6	0.4	-	15.7	10.2	2.7	-	-	12.9	7.9	2.1	-	-	10.0

APPENDIX 45

NUMBERS OF SPROUTS PER TUBER AT THE END OF THE SPROUTING PERIOD (11TH APRIL)

Storage Treatment	Arran Pilot						Majestic					
	d_1			d_2			d_1			d_2		
	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean
Stored at 65°–80°F without T.C.N.B.	11.5	8.9	10.2	16.4	11.4	13.9	5.8	5.2	5.5	6.7	5.8	6.2
Stored at 50°–60°F without T.C.N.B.	10.6	8.8	9.7	16.4	10.8	13.6	5.4	5.3	5.3	6.4	6.3	6.3
Stored at 40°F without T.C.N.B.	10.7	10.7	10.7	16.1	9.4	12.7	10.8	7.5	9.1	14.6	11.3	12.9
Stored at 65°–80°F with T.C.N.B.	12.7	9.7	11.2	9.0	10.3	9.6	8.0	7.4	7.7	9.3	8.6	8.9
Stored at 50°–60°F with T.C.N.B.	12.7	10.7	11.7	10.1	7.9	9.0	1.6	2.3	1.9	0.50	1.5	1.0
Stored at 40°F with T.C.N.B.	12.7	12.5	12.6	18.5	15.7	17.1	9.5	7.1	8.3	12.9	10.0	11.4
Mean	11.8	10.2	11.0	14.4	10.9	12.6	6.8	5.8	6.3	8.4	7.2	7.8

d_1 = desprouted on 4.1.61.

d_2 = desprouted on 20.2.61.

APPENDIX 46

NUMBERS OF SPROUTED EYES PER TUBER AT THE END OF THE SPROUTING PERIOD (11TH APRIL)

Storage treatment	Arran Pilot						Majestic					
	d_1			d_2			d_1			d_2		
	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean
Stored at 65°F-80°F without T.C.N.B.	8.3	7.6	7.90	10.0	8.2	9.1	4.9	4.7	4.8	5.0	5.4	5.2
Stored at 50°F-60°F without T.C.N.B.	7.9	6.9	7.40	9.6	7.5	8.5	4.5	4.4	4.4	4.1	4.9	4.5
Stored at 40°F without T.C.N.B.	8.9	7.4	8.10	10.1	7.8	8.9	7.4	5.7	6.5	8.6	7.8	8.2
Stored at 65°F-80°F with T.C.N.B.	7.2	6.5	6.80	5.7	6.7	6.2	5.4	5.7	5.5	5.5	4.5	5.0
Stored at 50°F-60°F with T.C.N.B.	7.7	6.1	6.90	5.3	5.8	5.5	1.2	1.5	1.3	0.5	0.5	0.5
Stored at 40°F with T.C.N.B.	8.3	7.9	8.10	10.2	9.6	9.9	7.5	6.2	6.8	8.0	7.6	7.8
Mean	8.0	7.1	7.5	8.5	7.6	8.0	5.1	4.7	4.9	5.3	5.1	5.2

d_1 = Desprouted on 4.1.61

d_2 = Desprouted on 20.2.61

[redacted]

APPENDIX 47

EFFECT OF PREVIOUS STORAGE TREATMENTS ON NUMBERS OF EYES HAVING ONE OR MORE SPROUTS AT THE END OF THE SPROUTING PERIOD (11th APRIL)

Arran Pilot

Number of eyes per tuber having one or more sprouts

Storage Treatment	Large Seed										Small Seed									
	d_1					d_2					d_1					d_2				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Stored at 65°-80°F without T.C.N.B.	6.0	1.4	0.9	-	-	5.6	2.7	1.4	0.3	-	6.6	0.8	0.1	0.1	-	5.6	2.0	0.6	-	-
Stored at 50°-60°F without T.C.N.B.	5.7	1.7	0.5	-	-	5.2	2.3	1.8	0.3	-	5.7	0.6	0.5	0.1	-	4.8	2.2	0.4	0.1	-
Stored at 40°F without T.C.N.B.	7.7	0.7	0.4	0.1	-	5.8	2.7	1.5	0.1	-	5.4	0.9	0.8	0.3	-	6.5	1.0	0.3	-	-
Stored at 65°-80°F with T.C.N.B.	3.7	2.0	1.1	0.3	0.1	3.5	1.3	0.7	0.2	-	4.1	1.6	0.8	-	-	4.3	1.5	0.6	0.3	-
Stored at 50°-60°F with T.C.N.B.	4.8	1.3	1.1	0.5	-	2.3	1.9	0.6	0.5	-	3.1	1.6	1.2	0.2	-	4.4	1.1	-	0.3	-
Stored at 40°F with T.C.N.B.	5.7	1.1	1.1	0.4	-	5.2	2.3	2.1	0.6	-	4.9	1.4	1.6	-	-	5.7	1.9	1.5	0.4	-

Majestic

Storage Treatment	Large Seed										Small Seed									
	d_1					d_2					d_1					d_2				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Stored at 65°-80°F without T.C.N.B.	4.3	0.4	0.1	0.1	-	3.9	0.6	0.4	0.1	-	4.2	0.5	-	-	-	5.0	0.4	-	-	-
Stored at 50°-60°F without T.C.N.B.	3.7	0.7	0.1	-	-	2.4	1.1	0.6	-	-	3.6	0.7	0.1	-	-	3.8	0.8	0.3	-	-
Stored at 40°F without T.C.N.B.	5.1	1.5	0.6	0.2	-	5.1	1.6	1.3	0.6	-	4.5	0.8	0.2	0.2	-	5.4	1.4	0.9	0.1	-
Stored at 65°-80°F with T.C.N.B.	3.5	1.2	0.7	-	-	3.2	1.3	0.6	0.3	0.1	4.5	0.8	0.3	0.1	-	1.8	1.6	0.8	0.3	-
Stored at 50°-60°F with T.C.N.B.	0.8	0.4	-	-	-	0.5	-	-	-	-	0.8	0.6	0.1	-	-	0.2	-	0.1	-	0.2
Stored at 40°F with T.C.N.B.	6.1	0.8	0.6	-	-	5.2	1.1	1.2	0.5	-	5.5	0.5	0.2	-	-	5.8	1.2	0.6	-	-

d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61

[redacted]

APPENDIX 48

FINAL PLANT STAND (%)

Storage Treatment	Final Stand of Plant (%)																	
	Arran Pilot									Majestic								
	d_1			d_2			d_3			d_1			d_2			d_3		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
Stored at 65°-80°F without T.C.N.B.	100	100	100	82.5	92.5	87.5	57.5	55.0	56.25	100.0	100.0	100.0	80.0	72.5	76.25	52.5	32.5	42.5
Stored at 50°-60°F without T.C.N.B.	100	100	100	100.0	100.0	100.0	47.5	47.5	47.5	100.0	100.0	100.0	100.0	100.0	100.0	85.0	92.5	88.75
Stored at 40°F without T.C.N.B.	100	100	100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Stored at 65°-80°F with T.C.N.B.	100	100	100	97.5	95.0	96.25	7.5	5.0	6.25	100.0	95.0	97.5	75.0	60.0	67.5	27.5	25.0	26.25
Stored at 50°-60°F with T.C.N.B.	100	100	100	100.0	87.5	93.75	27.5	37.5	32.50	27.5	45.0	36.25	10.0	15.0	12.5	7.5	20.0	13.75
Stored at 40°F with T.C.N.B.	100	100	100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

S_1 = Large seed
S_2 = Small seed

d_1 = Desprouted on 4.1.61
d_2 = Desprouted on 20.2.61
d_3 = Desprouted at the time of planting.

APPENDIX 49

PERCENTAGE EMERGENCE OF PLANTS AT DIFFERENT DATES AFTER PLANTING

Arran Pilot — Percentage of emergence of plant on different days after planting

Date of Desprouting	Storage Treatment	12 S_1	12 S_2	14 S_1	14 S_2	18 S_1	18 S_2	21 S_1	21 S_2	25 S_1	25 S_2	28 S_1	28 S_2	32 S_1	32 S_2	35 S_1	35 S_2	39 S_1	39 S_2
d_1 Desprouted on 4.1.61	Stored at 65°-80°F without T.C.N.B.	20.0	2.5	30.0	2.5	70.0	42.5	80.0	70.0	100	87.5	100	97.5	100	100				
	Stored at 50°-60°F without T.C.N.B.	5.0	7.5	5.0	12.5	52.5	35.0	75.0	57.5	97.5	92.5	100	95.0	100	97.5	100	100		
	Stored at 40°F without T.C.N.B.	22.5	2.5	22.5	2.5	57.5	37.5	65.0	55.0	90.0	87.5	97.5	97.5	100	100				
	Stored at 65°-80°F with T.C.N.B.	10.0	5.0	10.0	5.0	70.0	52.5	75.0	57.5	100	90.0	100	97.5	100	97.5	100	100		
	Stored at 50°-60°F with T.C.N.B.	2.5	5.0	12.5	7.5	75.0	45.0	85.0	62.5	95.0	85.0	100	90.0	100	97.5	100	100		
	Stored at 40°F with T.C.N.B.	5.0	0	15.0	2.5	62.5	35.0	82.5	55.0	97.5	92.5	100	100						
d_2 Desprouted on 20.2.61	Stored at 65°-80°F without T.C.N.B.	0	2.5	0	2.5	17.5	20.0	27.5	42.5	52.5	80.0	62.		70.0	92.5	72.5	92.5	82.5	92.5
	Stored at 50°-60°F without T.C.N.B.	2.5	0	2.5	2.5	45.0	30.0	65.0	45.0	90.0	75.0	95.0	87.5	100	92.5	100	97.5	100	100
	Stored at 40°F without T.C.N.B.	2.5	2.5	5.0	2.5	32.5	17.5	60.0	45.0	95.0	92.5	100	100						
	Stored at 65°-80°F with T.C.N.B.	0	0	0	0	15.0	22.5	30.0	50.0	67.5	87.5	85.0	92.5	92.5	95.0	95.0	95.0	97.5	95.0
	Stored at 50°-60°F with T.C.N.B.	0	0	5.0	0	57.5	17.5	82.5	40.0	97.5	75.0	100	82.5	100	85.0	100	87.5	100	87.5
	Stored at 40°F with T.C.N.B.	2.5	2.5	7.5	2.5	27.5	30.0	62.5	45.0	97.5	95.0	100	100						
d_3 Desprouted at the time of planting	Stored at 65°-80°F without T.C.N.B.	0	0	0	0	0	0	0	0	0	2.5	0	5.0	7.5	10.0	15.0	22.5	47.5	42.5
	Stored at 50°-60°F without T.C.N.B.	0	0	0	0	0	0	0	0	0	2.5	5.0	5.0	25.0	22.5	37.5	25.0	60.0	42.5
	Stored at 40°F without T.C.N.B.	0	0	0	0	0	0	0	0	0	0	7.5	10.0	32.0	30.0	87.5	62.5	100	100
	Stored at 65°-80°F with T.C.N.B.	0	0	0	0	0	0	0	0	0	0	0	0	5.0	0	5.0	0	7.5	5.0
	Stored at 50°-60°F with T.C.N.B.	0	0	0	0	0	0	0	0	0	0	0	2.5	17.5	7.5	20.0	17.5	27.5	32.5
	Stored at 40°F with T.C.N.B.	0	0	0	0	0	0	0	0	0	12.5	5.0	12.5	37.5	40.0	80.0	75.0	100	100

Majestic — Percentage of emergence of plant on different days after planting

Date of Desprouting	Storage Treatment	12 S_1	12 S_2	14 S_1	14 S_2	18 S_1	18 S_2	21 S_1	21 S_2	25 S_1	25 S_2	28 S_1	28 S_2	32 S_1	32 S_2	35 S_1	35 S_2	39 S_1	39 S_2
d_1 Desprouted on 4.1.61	Stored at 65°-80°F without T.C.N.B.	5.0	0	7.5	2.5	62.5	30.0	70.0	47.5	92.5	77.5	97.5	95.0	100	100				
	Stored at 50°-60°F without T.C.N.B.	2.5	0	2.5	0	40.0	30.0	60.0	40.0	80.0	70.0	92.5	92.5	100	100				
	Stored at 40°F without T.C.N.B.	2.5	0	7.5	0	47.5	12.5	55.0	32.5	80.0	60.0	97.5	92.5	100	95.0	100	100		
	Stored at 65°-80°F with T.C.N.B.	5.0	0	7.5	0	62.5	35.0	80.0	40.0	95.0	67.5	97.5	85.0	97.5	90.0	100	95.0	100	95.0
	Stored at 50°-60°F with T.C.N.B.	0	0	0	0	5.0	12.5	12.5	20.0	15.0	30.0	22.5	30.0	22.5	32.5	22.5	32.5	22.5	37.5
	Stored at 40°F with T.C.N.B.	7.5	0	12.5	0	45.0	27.5	60.0	30.0	85.0	62.5	100	92.5	100	97.5	100	97.5	100	100
d_2 Desprouted on 20.2.61	Stored at 65°-80°F without T.C.N.B.	0	0	0	0	7.5	12.5	37.5	25.0	65.0	37.5	72.5	42.5	75.0	55.0	75.0	57.5	80.0	60.0
	Stored at 50°-60°F without T.C.N.B.	0	0	0	0	47.5	32.5	55.0	45.0	72.5	65.0	85.0	90.0	97.5	92.5	100	95.0	100	100
	Stored at 40°F without T.C.N.B.	0	0	0	0	22.5	5.0	37.5	10.0	67.5	40.0	82.5	70.0	100	90.0	100	100		
	Stored at 65°-80°F with T.C.N.B.	0	0	0	0	5.0	0	17.5	5.0	47.5	20.0	55.0	27.5	65.0	35.0	65.0	52.5	75.0	55.0
	Stored at 50°-60°F with T.C.N.B.	0	0	0	0	0	0	0	5.0	0	10.0	2.5	10.0	2.5	10.0	2.5	12.5	2.5	12.5
	Stored at 40°F with T.C.N.B.					37.5	27.5	40.0	30.0	65.0	55.0	85.0	77.5	100	90.0	100	100		
d_3 Desprouted at the time of planting	Stored at 65°-80°F without T.C.N.B.	0	0	0	0	0	0	0	0	0	0	0	0	12.5	2.5	30.0	12.5	37.5	27.5
	Stored at 50°-60°F without T.C.N.B.	0	0	0	0	0	0	2.5	0	17.5	12.5	42.5	27.5	65.0	65.0	67.5	75.0	85.0	87.5
	Stored at 40°F without T.C.N.B.	0	0	0	0	0	0	0	0	0	0	2.5	0	22.5	5.0	67.5	35.0	100	100
	Stored at 65°-80°F with T.C.N.B.	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	7.5	0	15.0	10.0
	Stored at 50°-60°F with T.C.N.B.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	7.5	20.0
	Stored at 40°F with T.C.N.B.	0	0	0	0	0	0	0	0	0	0	0	0	7.5	5.0	57.5	37.5	100	100

S_1 = Large Seed

S_2 = Small Seed

APPENDIX 50

GERMINATION RATE INDEX

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
Total whole plot	7	0.784625		
Replication	3	0.209167	0.069722	1.61
Variety (V)	1	0.445961	0.445961	10.33 **
Error 'a'	3	0.129497	0.043165	
Total sub plot	47	12.694125		
Whole plot	7	0.784625		
Date of desprouting (D)	2	11.193230	5.596615	886.52 **
Size of seed tuber (S)	1	0.151296	0.151296	23.96 **
Interactions: D x S	2	0.050791	0.025395	4.02 *
V x D	2	0.185101	0.092550	14.66 **
V x S	1	0.001845	0.001845	-
V x D x S	2	0.002224	0.001112	-
Error 'b'	30	0.189390	0.006313	
Total half sub plot	287	15.190677		
sub plot	47	12.694125		
Treatment (T)	5	0.349615	0.069923	12.31 **
Interactions: T x V	5	0.375790	0.075158	13.23 **
T x D	10	0.338791	0.033879	5.96 **
T x S	5	0.033364	0.006673	1.17
T x V x D	10	0.259976	0.025998	4.58 **
T x V x S	5	0.117373	0.023475	4.13 **
T x D x S	10	0.035822	0.003582	-
T x V x D x S	10	0.098843	0.009884	1.74
Error 'c'	180	1.022601	0.005681	

** Significant at 1%   * Significant at 5%

APPENDIX 51

GERMINATION RATE INDEX: TREATMENT x SEED SIZE

Storage Treatment	Seed Size		Mean
	Large	Small	
Stored at 65°-80°F without T.C.N.B.	0.500	0.454	0.477
" " 50°-60°F " "	0.545	0.500	0.522
" " 40°F " "	0.513	0.442	0.478
Stored at 65°-80°F with T.C.N.B.	0.471	0.411	0.441
" " 50°-60°F " "	0.415	0.413	0.414
" " 40°F " "	0.519	0.466	0.492
Mean	0.494	0.448	

S.E. of Seed size ± 0.006

S.E. of Treatment ± 0.011

S.E. of Treatment x Seed size ± 0.015

APPENDIX 52

GERMINATION RATE INDEX: TREATMENT x DATE OF DESPROUTING x SEED SIZE

Storage Treatment	Date of Desprouting								
	d_1			d_2			d_3		
	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean
Stored at 65°-80°F without T.C.N.B.	0.744	0.641	0.693	0.545	0.544	0.544	0.210	0.178	0.190
Stored at 50°-60°F without T.C.N.B.	0.673	0.628	0.651	0.646	0.583	0.614	0.315	0.290	0.302
Stored at 40°F without T.C.N.B.	0.692	0.597	0.644	0.614	0.540	0.577	0.233	0.190	0.212
Stored at 65°-80°F with T.C.N.B.	0.725	0.631	0.678	0.523	0.519	0.521	0.166	0.083	0.125
Stored at 50°-60°F with T.C.N.B.	0.685	0.628	0.656	0.412	0.450	0.431	0.149	0.161	0.155
Stored at 40°F with T.C.N.B.	0.712	0.607	0.660	0.625	0.586	0.605	0.219	0.205	0.212
Mean	0.705	0.622	0.663	0.561	0.537	0.549	0.215	0.185	0.200

S.E. of Date of desprouting ± 0.008
S.E. of Date of desprouting x Seed size (D x S) ± 0.011
S.E. of Treatment x Date of desprouting x Seed size ± 0.027
S.E. of Treatment x Date of desprouting ±0.019

APPENDIX 53

GERMINATION RATE INDEX:
TREATMENT x VARIETY x SEED SIZE

Storage Treatment	Arran Pilot			Majestic			Mean
	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	
Stored at 65°-80°F without T.C.N.B.	0.485	0.491	0.488	0.515	0.418	0.466	0.477
Stored at 50°-60°F without T.C.N.B.	0.546	0.499	0.523	0.548	0.501	0.522	0.522
Stored at 40°F without T.C.N.B.	0.547	0.497	0.522	0.478	0.388	0.433	0.478
Stored at 65°-80°F with T.C.N.B.	0.490	0.451	0.470	0.453	0.371	0.412	0.441
Stored at 50°-60°F with T.C.N.B.	0.567	0.487	0.527	0.264	0.340	0.302	0.414
Stored at 40°F with T.C.N.B.	0.549	0.514	0.531	0.489	0.418	0.453	0.492
Mean	0.531	0.490	0.510	0.457	0.406	0.431	

S.E. of Variety $\pm$ 0.017
S.E. of V x S $\pm$ 0.009
S.E. of Treatment $\pm$ 0.011
S.E. of T x V x S $\pm$ 0.022
S.E. of T x V $\pm$ 0.015

APPENDIX 54

GERMINATION RATE INDEX:
TREATMENT x VARIETY x DATE OF DESPROUTING x SEED SIZE

Storage Treatment	Arran Pilot						Majestic					
	d_1		d_2		d_3		d_1		d_2		d_3	
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed
Stored at 65°-80°F without T.C.N.B.	0.778	0.669	0.514	0.614	0.162	0.189	0.711	0.614	0.575	0.474	0.258	0.166
Stored at 50°-60°F without T.C.N.B.	0.705	0.664	0.672	0.589	0.261	0.245	0.641	0.592	0.619	0.578	0.368	0.334
Stored at 40°F without T.C.N.B.	0.728	0.647	0.661	0.619	0.252	0.225	0.655	0.547	0.566	0.461	0.214	0.155
Stored at 65°-80°F with T.C.N.B.	0.739	0.672	0.536	0.627	0.194	0.055	0.711	0.590	0.509	0.412	0.139	0.111
Stored at 50°-60°F with T.C.N.B.	0.744	0.658	0.714	0.604	0.243	0.198	0.625	0.598	0.111	0.296	0.555	0.125
Stored at 40°F with T.C.N.B.	0.736	0.650	0.664	0.638	0.247	0.252	0.689	0.564	0.586	0.533	0.191	0.158
Mean	0.738	0.660	0.627	0.615	0.227	0.194	0.672	0.584	0.494	0.459	0.204	0.175

S.E. of V x D x S $\pm$ 0.16   S.E. of T x V x D x S $\pm$ 0.038

APPENDIX 55

EFFECT OF DIFFERENT STORAGE TREATMENTS ON THE DRY MATTER (GM.) PRODUCTION OF TUBERS AND FOLIAGE PER PLANT AT DIFFERENT STAGES OF PLANT GROWTH

Date of Desprouting	Storage Treatment	Arran Pilot							
		Large Seed							
		56 days		77 days		98 days		119 days	
		G.S.	T.	G.S.	T.	G.S.	T.	G.S.	T.
d_1 Desprouted on 4.1.61	Stored at 65°-80°F without T.C.N.B.	4.83	8.00	2.33	11.67	1.67	28.67	-	33.33
	Stored at 50°-60°F without T.C.N.B.	12.33	20.00	22.00	76.33	17.00	100.33	1.33	21.33
	Stored at 40°F without T.C.N.B.	22.50	37.0	34.0	92.67	48.67	203.66	5.67	138.33
	Stored at 65°-80°F with T.C.N.B.	2.67	7.83	1.0	10.0	6.0	57.33	-	28.67
	Stored at 50°-60°F with T.C.N.B.	11.12	19.67	13.0	61.67	17.67	89.0	37.0	18.33
	Stored at 40°F with T.C.N.B.	18.33	14.50	32.0	80.67	31.67	164.33	12.33	169.0
d_2 Desprouted on 20.2.61	Stored at 65°-80°F without T.C.N.B.	0.02	4.67	-	6.67	-	7.0	-	6.33
	Stored at 50°-60°F without T.C.N.B.	8.67	17.83	3.0	17.67	6.0	31.0	3.0	21.67
	Stored at 40°F without T.C.N.B.	27.0	10.33	28.33	93.67	51.33	167.33	12.67	176.33
	Stored at 65°-80°F with T.C.N.B.	0.60	3.67	-	5.0	-	10.0	1.67	29.0
	Stored at 50°-60°F with T.C.N.B.	5.33	9.67	4.0	23.67	6.33	37.33	0.67	20.33
	Stored at 40°F with T.C.N.B.	31.17	14.67	25.33	85.33	20.67	104.0	9.0	121.67
d_3 Desprouted at the time of planting	Stored at 65°-80°F without T.C.N.B.	-	-	-	1.83	2.67	2.67	-	0.67
	Stored at 50°-60°F without T.C.N.B.	-	-	2.0	3.5	1.67	8.67	-	5.67
	Stored at 40°F without T.C.N.B.	12.33	1.47	35.0	59.33	51.67	170.67	42.0	231.33
	Stored at 65°-80°F with T.C.N.B.	0.30	0.08	-	-	-	-	-	-
	Stored at 50°-60°F with T.C.N.B.	0.73	6.83	-	6.33	8.67	36.0	20.33	28.0
	Stored at 40°F with T.C.N.B.	15.33	4.0	24.67	33.67	33.33	122.33	25.67	169.67

G.S. = Green Shoot

T. = Tuber.

Arran Pilot								Majestic															
Small Seed								Large Seed								Small Seed							
56 days		77 days		98 days		119 days		56 days		77 days		98 days		119 days		56 days		77 days		98 days		119 days	
G.S.	T.	G.S.	T	G.S.	T.	G.S.	T.	G.S.	T.	G.S.	T.	G.S.	T.	G.S.	T.	G.S.	T.	G.S.	T.	G.S.	T.	G.S.	T.
5.33	10.83	2.0	7.67	5.0	14.33	-	28.67	32.67	26.67	44.33	91.67	50.33	172.33	29.67	194.33	23.17	15.33	24.33	48.67	55.67	150.33	32.0	184.33
10.12	13.0	6.67	10.67	8.0	55.33	3.0	63.33	37.50	16.33	46.67	57.33	58.67	201.0	46.67	280.0	27.33	12.33	27.67	43.67	58.67	181.67	34.67	188.67
17.0	21.67	39.33	56.0	12.67	146.0	12.33	146.67	32.17	8.67	55.0	87.0	52.67	178.33	51.67	303.0	29.33	6.83	48.33	48.0	54.67	152.0	35.0	195.67
0.25	2.67	3.33	5.0	5.33	26.67	-	10.67	24.67	21.83	22.33	53.0	41.0	145.33	27.67	181.67	24.33	11.33	22.33	40.0	35.67	123.0	11.67	93.67
2.5	5.33	6.67	46.83	2.27	12.0	1.0	34.0	17.67	10.67	21.33	35.0	57.67	190.67	0	191.67	9.0	4.33	23.0	44.0	25.33	69.0	9.33	77.0
17.67	12.33	39.0	67.33	17.33	88.0	6.0	94.67	30.0	13.83	54.33	92.67	65.0	195.0	51.67	306.67	24.83	5.67	27.33	27.33	64.0	159.33	48.33	210.67
2.83	4.0	-	4.67	-	4.33	-	1.67	10.33	16.50	15.67	21.06	0	12.67	5.0	40.0	0	7.0	4.0	10.0	23.0	51.0	0	1.67
8.0	12.0	5.0	12.33	4.0	29.33	-	5.0	21.33	18.67	36.67	69.0	14.67	51.67	19.0	138.67	18.0	9.67	33.67	63.33	31.67	116.33	16.0	106.0
20.0	11.0	30.33	59.33	35.33	131.0	11.33	124.67	42.33	23.33	58.67	103.67	103.67	276.67	54.33	287.23	27.5	8.50	44.67	64.33	82.0	167.67	52.67	245.33
3.17	8.0	2.67	11.33	1.67	12.0	1.33	24.33	14.5	15.68	8.0	16.0	0.33	5.33	0	6.0	0	0	5.33	11.37	0	2.33	0	3.00
0.90	2.17	22.0	15.33	3.33	24.33	-	3.0	0	0	4.0	6.67	0	0	0.67	5.33	0	0	3.67	11.33	32.67	68.33	10.67	40.67
16.50	7.17	21.67	48.0	13.67	66.67	6.0	109.33	41.33	22.0	49.67	65.33	66.0	158.67	47.67	249.0	24.0	8.67	40.0	62.67	59.0	148.67	57.67	237.33
0.33	0.16	3.90	7.67	4.67	15.67	1.67	7.67	1.53	3.83	0	4.0	3.83	7.67	0	1.0	0.73	0.03	5.67	4.67	0	1.33	4.0	17.67
0.68	0.38	3.5	0.43	1.33	3.67	-	1.83	0.25	6.0	13.0	29.33	4.33	17.0	1.67	34.33	1.25	5.67	6.67	12.0	4.0	50.67	0	3.0
12.33	3.0	32.0	54.67	57.0	157.0	17.33	148.33	19.0	0.35	61.67	49.33	79.0	166.67	67.0	221.67	13.83	0.53	50.67	56.67	102.33	177.33	56.33	230.33
-	-	-	-	3.67	8.0	-	-	0.18	0.87	0	0.17	9.67	11.67	8.33	33.33	0	0	0	0	0	0	1.67	2.0
0.35	2.33	0.7	1.7	10.3	48.0	-	4.67	0	0	0	0	0	0	0	1.33	0	0	0	0	3.0	17.0	4.67	18.33
23.50	4.0	26.33	48.17	52.67	106.0	30.0	175.0	23.5	3.83	69.67	51.67	75.67	174.33	56.67	269.0	15.50	3.25	19.67	28.33	42.67	93.0	58.33	207.67

APPENDIX 56

NUMBER OF TUBER-PRODUCING STEMS PER PLANT (AVERAGE OF THREE DATES OF SAMPLING)

Date of Desprouting	Storage Treatment	Number of tuber bearing stems from main stem) (Main stem + Underground branches per plant.											
		Arran Pilot						Majestic					
		Large Seed			Small Seed			Large Seed			Small Seed		
		M.S.[1]	U.B.[2]	Total	M.S.	U.B.	Total	M.S.	U.B.	Total	M.S.	U.B.	Total
d_1 i.e. Desprouted on 4.1.61	Stored at 65°-80°F without T.C.N.B.	1.11	0.44	1.55	1.00	1.10	2.11	2.89	1.22	4.11	2.00	0.89	2.89
	" " 50°-60°F " "	2.56	4.78	7.34	1.55	1.89	3.44	2.00	1.67	3.67	1.33	2.67	4.00
	" " 40°F " "	3.00	7.89	10.89	1.89	4.67	6.56	1.78	2.44	4.22	1.56	2.11	3.67
	Stored at 65°-80°F with T.C.N.B.	1.00	0.33	1.33	0.78	0.33	1.11	2.56	1.22	3.78	2.00	1.67	3.67
	" " 50°-60°F " "	2.11	4.67	6.78	1.22	1.0	2.22	1.89	0.33	2.22	1.44	0.89	2.33
	" " 40°F " "	3.11	8.33	11.44	1.78	5.67	7.45	1.56	3.66	5.22	1.67	1.89	3.56
d_2 i.e. Desprouted on 20.2.61	Stored at 65°-80°F without T.C.N.B.	0.11	0.22	0.33	0.11	0.44	0.55	0.89	0.33	1.22	0.67	0.22	0.89
	" " 50°-60°F " "	1.33	1.44	2.77	1.67	2.33	4.00	1.67	0.11	1.78	2.11	0.78	2.89
	" " 40°F " "	4.44	7.67	12.11	2.89	7.33	10.22	3.11	2.89	6.00	1.88	1.88	3.76
	Stored at 65°-80°F with T.C.N.B.	0.33	0.11	0.44	1.11	0.44	1.55	1.44	0.22	1.66	0.22	0	0.22
	" " 50°-60°F " "	2.22	1.89	4.11	1.33	0.78	2.11	0.33	0	0.33	0.67	0	0.67
	" " 40°F " "	3.66	7.22	10.88	2.22	5.56	7.78	.33	1.33	4.66	2.22	2.44	4.66
d_3 i.e. Desprouted at the time of Planting	Stored at 65°-80°F without T.C.N.B.	0.33	0.11	0.44	1.00	0	1.00	0.67	0.11	0.78	0.44	0	0.44
	" " 50°-60°F " "	0.89	0	0.89	0.89	0.22	1.11	1.22	0.11	1.33	0.55	0	0.55
	" " 40°F " "	7.11	2.00	9.11	6.33	1.56	7.89	3.56	0.78	4.34	3.89	0.11	4.00
	Stored at 65°-80°F with T.C.N.B.	0.11	0	0.11	0.89	0	0.89	0.55	0.22	0.77	0.11	0	0.11
	" " 50°-60°F " "	0.77	0.89	1.67	0.89	0.44	1.33	0.11	0.11	0.22	0.33	0	0.33
	" " 40°F " "	6.67	3.33	10.00	4.88	2.50	7.38	4.67	-	4.67	4.00	0.63	4.63

[1] M.S. = Main Stem

[2] U.B. = Underground branches from main stem.

APPENDIX 57

EFFECT OF DIFFERENT STORAGE TREATMENTS ON THE NUMBER OF AERIAL STEMS

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
Total whole plot	7	117059.264		
Replication	3	2502.403	834.134	4.52
Variety (V)	1	114003.125	114003.125	617.64 **
Error 'a'	3	553.736	184.579	
Total sub plot	47	273285.208		
Whole plot	7	117059.264		
Date of desprouting (D)	2	100911.083	50455.541	274.18 **
Size of seed tuber (S)	1	7401.389	7401.389	40.22 **
Interactions: D x S	2	2138.111	1069.055	5.81 **
V x D	2	35058.334	17529.167	95.25 **
V x S	1	2134.222	2134.222	11.60 **
V x D x S	2	3062.028	1531.014	8.32 **
Error 'b'	30	5520.777	184.026	
Total half sub plot	287	440761.875		
Sub plot	47	273285.208		
Treatment (T)	5	107252.958	21450.592	265.55 **
Interactions: T x V	5	19795.959	3959.192	49.01 **
T x D	10	9411.834	941.183	11.65 **
T x S	5	4023.695	804.739	9.96 **
T x V x D	10	4027.332	402.733	4.99 **
T x V x S	5	3119.860	623.972	7.72 **
T x D x S	10	2574.055	257.405	3.19 **
T x V x D x S	10	2730.890	273.089	3.38 **
Error 'c'	180	14540.084	80.778	

** Significant at 1%

APPENDIX 58

NUMBER OF TUBERS PER PLANT IN TWO SEED SIZES OF TWO VARIETIES AT DIFFERENT STAGES OF PLANT GROWTH

Date of Desprouting	Storage Treatment	Arran Pilot												Majestic											
		Number of tubers per plant on different dates after planting																							
		56			77			98			119			56			77			98			119		
		Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean
d_1 Desprouted on 4.1.61	Stored at 65°-80°F without T.C.N.B.	12.67	8.33	10.50	10.33	4.67	7.50	10.33	6.33	8.33	5.0	4.67	4.83	28.0	19.0	23.50	10.67	5.0	7.83	13.33	8.67	11.0	9.00	8.67	8.83
	Stored at 50°-60°F without T.C.N.B.	11.00	13.33	12.16	15.67	8.00	11.83	8.33	8.00	8.16	9.67	10.00	9.83	17.67	17.00	17.33	17.33	14.33	15.83	16.00	9.67	12.83	12.67	6.0	9.33
	Stored at 40°F without T.C.N.B.	11.00	5.67	8.33	15.00	16.00	15.50	19.00	12.67	15.83	10.33	9.67	10.00	16.67	16.33	16.50	21.67	15.33	18.50	12.67	13.0	12.83	7.33	8.0	7.66
	Stored at 65°-80°F with T.C.N.B.	10.00	8.33	9.16	9.33	2.33	5.83	13.33	10.33	11.83	11.33	6.0	8.67	25.00	15.33	20.16	15.33	11.0	13.16	16.0	6.33	11.16	17.0	8.33	12.66
	Stored at 50°-60°F with T.C.N.B.	15.00	9.33	12.16	16.33	12.67	14.50	27.33	4.67	16.00	10.67	6.67	8.67	19.67	9.67	14.67	11.33	9.67	10.50	14.33	6.33	10.33	7.0	6.67	6.83
	Stored at 40°F with T.C.N.B.	17.33	11.00	14.16	22.67	13.00	17.83	14.67	13.67	14.17	13.33	8.33	10.83	17.0	11.0	14.00	13.67	8.33	11.0	12.67	10.0	11.33	11.67	4.67	8.17
d_2 Desprouted on 20.2.61	Stored at 65°-80°F without T.C.N.B.	6.67	8.00	7.33	4.0	3.67	3.83	8.33	4.67	6.50	9.00	2.33	5.66	8.0	2.0	5.0	9.67	2.33	6.0	4.33	5.0	4.66	4.67	1.33	3.00
	Stored at 50°-60°F without T.C.N.B.	8.33	8.67	8.50	8.33	4.33	6.33	6.67	10.33	8.50	4.00	5.00	4.50	8.33	16.33	12.33	15.33	16.33	15.83	8.0	7.33	7.66	11.67	6.0	8.83
	Stored at 40°F without T.C.N.B.	24.33	20.67	22.50	17.67	20.00	18.83	16.33	12.00	14.16	9.67	14.33	12.00	30.0	15.0	22.5	20.67	12.00	16.33	11.0	10.67	10.83	13.33	13.33	13.33
	Stored at 65°-80°F with T.C.N.B.	4.67	11.33	8.00	8.67	7.67	8.17	6.00	4.67	5.33	13.33	8.67	11.00	12.67	0	6.33	12.33	4.33	8.33	4.0	4.33	4.16	3.0	1.0	2.0
	Stored at 50°-60°F with T.C.N.B.	12.00	6.33	9.16	10.33	11.00	10.66	17.67	6.33	12.0	12.67	3.00	7.83	0	0	0	4.0	8.33	6.16	0	6.0	3.0	2.33	2.00	2.16
	Stored at 40°F with T.C.N.B.	29.67	7.67	18.67	14.67	14.00	14.33	12.33	10.33	11.33	11.33	10.33	10.83	18.33	12.0	15.16	11.33	11.33	11.33	13.0	9.0	11.0	7.67	9.33	8.50
d_3 Desprouted at the time of planting	Stored at 65°-80°F without T.C.N.B.	0	0.67	0.33	1.33	4.33	2.83	2.00	4.33	3.16	1.00	1.00	1.00	3.67	1.0	2.33	2.67	5.0	3.83	3.67	1.67	2.67	1.33	3.0	2.16
	Stored at 50°-60°F without T.C.N.B.	0	1.33	0.66	0.67	1.67	1.17	3.00	3.00	3.00	1.33	1.33	1.33	5.67	4.33	5.0	9.00	4.67	6.83	3.33	4.0	3.66	3.67	1.0	2.33
	Stored at 40°F without T.C.N.B.	9.67	15.67	12.67	23.33	12.00	17.66	14.00	14.00	14.00	15.33	16.00	15.66	8.33	5.33	6.83	17.67	22.67	20.17	17.33	16.33	16.83	11.67	9.67	10.67
	Stored at 65°-80°F with T.C.N.B.	0.33	0	0.16	0	0	0	0	3.00	1.50	0	0	0	3.00	0	1.50	1.33	0	0.66	4.67	0	2.33	7.33	0.67	4.0
	Stored at 50°-60°F with T.C.N.B.	9.33	5.67	7.50	6.67	2.00	4.33	4.33	6.00	5.16	6.67	4.33	5.50	0	0	0	0	0	0	0	2.67	1.33	1.0	2.0	1.50
	Stored at 40°F with T.C.N.B.	17.00	18.50	17.75	12.00	14.00	13.00	12.33	9.33	10.83	17.67	14.33	16.00	18.67	17.0	17.83	18.67	15.33	17.0	17.33	18.33	17.83	17.33	12.67	15.0
	Mean	11.05	8.92	9.98	10.94	8.41	9.67	10.89	7.98	9.43	9.02	7.00	8.01	13.37	8.96	11.16	11.81	9.22	10.52	9.54	7.74	8.64	8.31	5.80	7.05

APPENDIX 59

SIZE OF TUBERS PER PLANT AT DIFFERENT STAGES OF PLANT GROWTH

Date of Desprouting	Storage Treatment	Arran Pilot									
		Days after planting									
		56					77				
		Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total
		0-1	1-3	3-5	5		0-1	1-3	3-5	5	
d_1 Desprouted on 4.1.61	Stored at 65°-80°F without T.C.N.B.	2.5	7.83	0.17	-	10.50	2.66	4.17	0.67	-	7.50
	Stored at 50°-60°F without T.C.N.B.	5.16	6.00	1.0	-	12.16	2.66	5.34	3.33	0.50	11.83
	Stored at 40°F without T.C.N.B.	3.0	1.99	3.17	0.17	8.33	3.00	5.33	6.67	0.50	15.50
	Stored at 65°-80°F with T.C.N.B.	3.33	5.83	-	-	9.16	1.50	4.33	-	-	5.83
	Stored at 50°-60°F with T.C.N.B.	3.17	8.33	0.66	-	12.16	3.33	7.67	3.33	0.17	14.50
	Stored at 40°F with T.C.N.B.	6.33	7.16	0.50	0.17	14.16	5.0	5.50	6.00	1.33	17.83
d_2 Desprouted on 20.2.61	Stored at 65°-80°F without T.C.N.B.	2.67	4.66	-	-	7.33	-	3.50	0.33	-	3.83
	Stored at 50°-60°F without T.C.N.B.	1.67	5.66	1.16	-	8.49	0.50	4.33	1.50	-	6.33
	Stored at 40°F without T.C.N.B.	12.83	9.50	0.17	-	22.50	5.67	4.34	8.50	0.32	18.83
	Stored at 65°-80°F with T.C.N.B.	3.17	4.50	0.33	-	8.00	2.17	5.83	0.17	-	8.17
	Stored at 50°-60°F with T.C.N.B.	4.16	4.33	0.67	-	9.16	1.67	6.16	2.83	-	10.66
	Stored at 40°F with T.C.N.B.	7.83	10.67	0.17	-	18.67	3.00	3.16	7.67	0.50	14.33
d_3 Desprouted before planting	Stored at 65°-80°F without T.C.N.B.	-	-	0.33	-	0.33	0.67	2.66	0.50	-	2.83
	Stored at 50°-60°F without T.C.N.B.	0.50	0.16	-	-	0.66	0.33	0.67	0.17	-	1.17
	Stored at 40°F without T.C.N.B.	6.00	6.67	-	-	12.67	5.67	6.16	5.83	-	17.66
	Stored at 65°-80°F with T.C.N.B.	-	0.16	-	-	0.16	-	-	-	-	-
	Stored at 50°-60°F with T.C.N.B.	1.33	6.17	-	-	7.50	0.66	3.50	0.17	-	4.33
	Stored at 40°F with T.C.N.B.	7.55	10.20	-	-	17.75	3.83	5.17	3.50	0.50	13.00

Arran Pilot										Majestic																			
										Days after planting																			
98					119					56					77					98					119				
Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total
0-1	1-3	3-5	5		0-1	1-3	3-5	5		0-1	1-3	3-5	5		0-1	1-3	3-5	5		0-1	1-3	3-5	5		0-1	1-3	3-5	5	
0.66	6.50	1.17	-	8.34	0.16	4.17	0.50	-	4.83	10.33	11.50	1.67	-	23.50	2.0	1.50	2.66	1.66	7.82	1.33	3.33	3.34	3.00	11.00	-	0.83	3.83	4.17	8.83
0.16	4.00	3.50	0.50	8.16	0.83	6.33	2.50	0.17	9.83	4.66	11.50	1.17	-	17.33	5.17	4.83	5.50	0.33	15.83	2.0	2.84	4.66	3.33	12.83	0.17	1.83	4.00	3.33	9.33
1.16	6.00	7.33	1.33	15.82	0.33	1.84	6.50	1.33	10.00	8.33	8.00	0.17	-	16.50	7.0	5.33	4.50	1.67	18.50	1.66	4.50	3.67	3.00	12.83	0.16	1.66	1.50	4.34	7.67
1.0	8.50	2.33	-	11.33	1.83	5.83	1.00	-	8.66	7.16	11.67	1.33	-	20.16	3.16	3.34	5.66	-	13.16	1.33	3.83	3.50	2.50	11.16	1.83	5.34	4.33	1.16	12.66
3.67	9.84	2.32	0.17	16.0	1.0	6.67	1.00	-	8.67	7.0	7.50	0.17	-	14.67	2.33	3.67	3.83	0.67	10.50	0.83	2.83	4.50	2.17	10.33	0.33	2.00	2.84	1.66	6.83
2.33	6.50	2.67	2.67	14.17	0.33	4.17	4.50	1.83	10.83	4.50	9.16	0.34	-	14.00	3.67	2.00	4.16	1.17	11.00	1.17	2.17	4.66	3.33	11.33	0.67	1.66	2.0	3.83	8.16
1.0	5.16	0.33	-	6.49	0.50	0.66	-	-	5.66	0.67	2.83	1.33	0.17	5.0	1.50	2.67	1.83	-	6.00	0.16	2.50	1.67	0.33	4.66	0.17	1.50	1.33	-	3.00
1.50	5.66	1.33	-	8.49	0.17	3.50	0.83	-	4.50	3.33	6.83	2.17	-	12.33	4.50	4.99	4.50	1.84	15.83	0.50	2.66	3.16	1.34	7.66	-	3.83	3.16	1.84	8.83
1.50	3.50	7.33	1.83	14.16	0.50	3.00	6.50	2.00	12.00	8.66	12.58	1.25	-	22.49	3.50	4.49	5.84	2.50	16.33	1.0	1.83	4.0	4.00	10.83	1.0	4.0	4.33	4.00	13.33
-	4.50	0.83	-	5.33	1.33	7.33	2.34	-	11.00	2.33	3.50	0.50	-	6.33	2.17	4.67	1.49	-	8.33	0.33	3.83	-	-	4.16	-	2.0	-	-	2.00
1.67	8.50	1.83	-	12.0	0.67	6.66	5.0	-	7.83	-	-	-	-	-	2.33	2.16	1.66	-	6.15	0.17	0.84	1.66	0.33	3.00	0.5	1.16	0.33	0.17	2.16
0.83	5.0	4.83	0.67	11.33	0.50	4.00	4.83	1.50	10.83	5.5	8.33	1.00	-	15.16	1.67	3.50	4.83	1.33	11.33	0.50	3.84	3.33	3.33	11.0	0.17	1.83	2.50	4.00	8.50
0.83	1.66	0.50	0.17	3.16	-	0.67	0.33	-	1.00	1.5	0.83	-	-	2.33	2.0	1.17	0.67	-	3.83	0.67	1.67	0.33	-	2.67	0.33	1.16	0.67	-	2.16
0.50	2.33	0.17	-	3.00	0.33	1.00	-	-	1.33	1.83	2.50	0.67	-	5.0	1.83	3.00	1.83	0.17	6.83	0.67	1.33	1.33	0.33	3.66	-	1.16	1.17	-	2.33
0.33	5.17	6.16	2.34	14.00	0.50	5.16	6.83	3.17	15.66	5.33	1.50	-	-	6.83	6.0	6.17	7.33	0.67	20.17	1.83	4.83	4.00	1.67	16.83	0.33	2.00	4.50	3.83	10.66
-	1.33	0.17	-	1.50	-	-	-	-	-	0.50	1.0	-	-	1.50	0.5	0.16	-	-	0.66	1.00	1.00	0.33	-	2.33	0.67	2.33	1.00	-	4.0
0.66	2.83	1.66	-	5.16	0.16	4.00	1.17	0.17	5.50	-	-	-	-	-	-	-	-	-	-	0.17	0.83	0.33	-	1.33	-	1.16	0.33	-	1.49
0.33	4.00	5.50	1.00	10.83	0.50	5.50	7.83	2.17	16.00	9.66	8.00	0.17	-	17.83	4.0	6.33	6.17	0.50	17.00	2.66	5.50	9.17	1.00	17.83	1.0	4.50	6.33	3.17	15.0

APPENDIX 60

TOTAL YIELD (WARE + SEED + CHAT) OF TUBERS

(ANALYSIS OF VARIANCE)

Factor		d.f	S.Sq.	M.S.Sq.	Variance Ratio
Total whole plot		7	7067.368		
Replication		3	1938.075	646.025	15.72 *
Variety (V)		1	5005.919	5005.919	121.72 **
Error 'a'		3	123.374	41.125	
Total sub plot		47	15279.136		
Whole plot i.e. sub plot block		7	7067.368		
Date of desprouting (D)		2	6995.361	3497.680	186.41 **
Size of seed tuber (S)		1	194.818	194.818	10.38 **
Interactions:	D x S	2	47.422	23.711	1.26
	V x D	2	286.006	143.003	7.62 **
	V x S	1	0.605	0.605	-
	V x D x S	2	124.650	62.325	3.32
Error 'b'		30	562.906	18.763	
Total half sub plot		287	52477.539		
Sub plot		47	15279.136		
Treatment (T)		5	25327.452	5065.490	307.07 **
Interactions:	T x V	5	3782.617	756.523	45.86 **
	T x D	10	3191.606	319.161	19.35 **
	T x S	5	32.086	6.417	-
	T x V x D	10	977.606	97.761	5.93 **
	T x V x S	5	559.791	111.958	6.79 **
	T x D x S	10	224.075	22.407	1.36
	T x V x D x S	10	133.884	13.388	-
Error 'c'		180	2969.286	16.496	

** Significant at 1% * Significant at 5%

APPENDIX 61

YIELD - TONS/ACRE: TREATMENT x DATE OF DESPROUTING

Storage Treatment	Date of Desprouting d_1	d_2	d_3	Mean
Stored at 65°-80°F without T.C.N.B.	16.840	10.084	8.254	11.725
" " 50°-60°F " "	19.819	15.869	9.961	15.216
" " 40°F " "	21.780	21.590	21.203	21.524
Stored at 65°-80°F with T.C.N.B.	16.098	12.263	3.245	10.535
" " 50°-60°F " "	11.668	6.322	3.897	7.296
" " 40°F " "	22.732	21.333	20.662	21.572
Mean	18.156	14.575	11.203	

S.E. of Date of desprouting $\pm$ 0.254

S.E. of Treatment $\pm$ 0.337

S.E. of Treatment x Date of desprouting $\pm$ 0.585

APPENDIX 62

TOTAL YIELD (TONS/ACRE): TREATMENT x SEED SIZE

Storage Treatment	Seed Size Large	Seed Size Small	Mean
Stored at 65°-80°F without T.C.N.B.	12.244	11.207	11.725
" " 50°-60°F " "	15.699	14.734	15.216
" " 40°F " "	22.325	20.723	21.524
Stored at 65°-80°F with T.C.N.B.	11.013	10.057	10.535
" " 50°-60°F " "	7.438	7.153	7.296
" " 40°F " "	21.992	21.153	21.572
Mean	15.119	14.171	

S.E. of Seed size $\pm$ 0.208

S.E. of Treatment $\pm$ 0.337

S.E. of Treatment x Seed Size $\pm$ 0.474

APPENDIX 63

TOTAL YIELD (TONS/ACRE): TREATMENT x DATE OF DESPROUTING x SEED SIZE

Storage Treatment	Date of Desprouting								
	d_1			d_2			d_3		
	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean
Stored at 65°-80°F without T.C.N.B.	17.632	16.047	16.840	10.061	10.106	10.084	9.039	7.469	8.254
Stored at 50°-60°F without T.C.N.B.	21.068	18.570	19.819	16.227	15.511	15.869	9.802	10.120	9.961
Stored at 40°F without T.C.N.B.	22.590	20.970	21.780	21.860	21.320	21.590	22.527	19.879	21.203
Stored at 65°-80°F with T.C.N.B.	16.103	16.093	16.098	12.823	11.704	12.263	4.114	2.375	3.245
Stored at 50°-60°F with T.C.N.B.	13.136	10.199	11.668	6.289	6.355	6.322	2.890	4.905	3.897
Stored at 40°F with T.C.N.B.	23.231	22.234	22.732	21.946	20.700	21.323	20.800	20.524	20.662
Mean	18.960	17.352	18.156	14.868	14.282	14.575	11.529	10.879	11.203

S.E. of Date of desprouting ± 0.254
S.E. of Date of desprouting x Seed size ± 0.360
S.E. of Treatment x Date of desprouting x Seed size ± 0.827
S.E. of Treatment x Date of desprouting ± 0.585

APPENDIX 64

TOTAL YIELD (TONS/ACRE):
TREATMENT x VARIETY x DATE OF DESPROUTING x SEED SIZE

Storage Treatment	Arran Pilot						Majestic					
	d_1		d_2		d_3		d_1		d_2		d_3	
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed
Stored at 65°-80°F without T.C.N.B.	12.493	11.535	6.355	7.836	7.485	6.628	22.771	21.560	13.768	12.375	10.593	8.310
Stored at 50°-60°F without T.C.N.B.	17.476	14.544	12.426	11.701	4.638	3.986	24.660	22.596	20.027	19.320	14.966	16.255
Stored at 40°F without T.C.N.B.	20.457	16.553	19.156	17.857	20.495	18.066	24.723	25.387	24.563	24.872	24.558	21.692
Stored at 65°-80°F with T.C.N.B.	10.551	12.653	9.916	13.447	1.197	0.626	21.655	19.534	15.730	9.960	7.031	4.124
Stored at 50°-60°F with T.C.N.B.	17.245	10.282	11.291	9.004	3.848	4.405	9.027	10.117	1.287	3.705	1.932	5.404
Stored at 40°F with T.C.N.B.	19.644	18.027	17.047	18.312	17.667	16.917	26.817	26.441	26.844	23.087	23.933	24.131
Mean	16.311	13.766	12.698	13.026	9.222	8.438	21.609	20.939	17.037	15.538	13.835	13.319

S.E. of V x D x S ± 0.509 S.E. of T x V x D x S ± 1.170

APPENDIX 65

TOTAL NUMBER OF TUBERS (WARE + SEED + CHAT)

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
Total whole plot	7	86372.778		
Replication	3	26785.861	8928.620	5.57
Variety (V)	1	54780.500	54780.500	34.19**
Error 'a'	3	4806.417	1602.139	
Total sub plot	47	277535.500		
Whole plot i.e. sub plot block	7	86372.778		
Date of desprouting (D)	2	118912.646	59456.323	109.04**
Size of seed tuber (S)	1	12429.389	12429.389	22.79**
Interactions: D x S	2	5741.173	2870.586	5.26 *
V x D	2	32502.062	16251.031	29.80**
V x S	1	22.222	22.222	-
V x D x S	2	5196.675	2598.337	4.76 *
Error 'b'	30	16358 .555	545.285	
Total half sub plot	287	831175.500		
Sub plot	47	277535.500		
Treatment (T)	5	308665.042	61733.008	183.36**
Interactions: T x V	5	49024.375	9804.875	29.12**
T x D	10	89616.687	8961.669	26.62**
T x S	5	5024.736	1004.947	2.98 *
T x V x D	10	10526.188	1052.619	3.13**
T x V x S	5	17134.236	3426.847	10.18**
T x D x S	10	6068.077	606.808	1.80
T x V x D x S	10	6978.492	697.849	2.07 *
Error 'c'	180	60602.167	336.679	

** Significant at 1%   * Significant at 5%

APPENDIX 66

TOTAL NUMBER OF TUBERS (1000/ACRE): TREATMENT x DATE OF DESPROUTING

Storage Treatment	Date of Desprouting d_1	d_2	d_3	Mean
Stored at 65^o-80^oF without T.C.N.B.	148.10	97.36	73.81	106.42
" " 50^o-60^oF " "	178.27	136.81	73.16	129.41
" " 40^oF " "	183.11	191.74	195.21	190.02
Stored at 65^o-80^oF with T.C.N.B.	166.01	130.92	33.96	110.02
" " 50^o-60^oF " "	126.00	84.94	42.03	84.32
" " 40^oF " "	203.00	182.39	201.18	195.53
Mean	167.42	137.36	103.22	

S.E. of Date of desprouting $\pm$ 3.07

S.E. of Treatment $\pm$ 3.42

S.E. of Treatment x Date of desprouting $\pm$ 5.92

APPENDIX 67

TOTAL NUMBER OF TUBERS (1000/ACRE): TREATMENT x SEED SIZE

Storage Treatment	Seed Size		Mean
	Large	Small	
Stored at 65°-80°F without T.C.N.B.	113.52	99.33	106.42
" " 50°-60°F " "	136.86	121.97	129.41
" " 40°F " "	202.85	177.20	190.02
Stored at 65°-80°F with T.C.N.B.	109.71	110.89	110.29
" " 50°-60°F " "	91.64	77.01	84.32
" " 40°F " "	212.31	178.76	195.53
Mean	144.48	127.52	

S.E. of Seed size ± 2.50

S.E. of Treatment ± 3.42

S.E. of Treatment x Seed size ± 4.82

APPENDIX 63

TOTAL NUMBER OF TUBERS (1000/ACRE): TREATMENT x DATE OF DESPROUTING x SEED SIZE

Storage Treatment	Date of Desprouting								
	d_1			d_2			d_3		
	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean
Stored at 65°–80°F without T.C.N.B.	161.8	134.39	148.10	91.80	102.93	97.36	86.96	60.66	73.81
Stored at 50°–60°F without T.C.N.B.	197.47	159.10	178.27	141.49	132.13	136.81	73.63	74.70	73.16
Stored at 40°F without T.C.N.B.	199.25	166.98	183.11	199.57	183.92	191.74	209.73	180.69	195.21
Stored at 65°–80°F with T.C.N.B.	166.33	165.69	166.01	121.97	139.87	130.92	40.82	27.10	33.96
Stored at 50°–60°F with T.C.N.B.	147.13	104.87	126.00	92.93	76.95	84.94	34.85	49.21	42.03
Stored at 40°F with T.C.N.B.	231.19	174.88	203.04	194.41	170.37	182.39	211.35	191.02	201.18
Mean	183.87	150.98	167.42	140.36	134.36	137.36	109.22	97.37	103.22

S.E. of Date of desprouting ± 3.07
S.E. of Date of desprouting x Seed size ± 4.35
S.E. of Treatment x Date of desprouting ± 5.92
S.E. of Treatment x Date of desprouting x Seed size ± 8.37

APPENDIX 69

TOTAL NUMBER OF TUBERS (1000/ACRE):
TREATMENT x VARIETY x DATE OF DESPROUTING x SEED SIZE

Storage Treatment	Arran Pilot						Majestic					
	d_1		d_2		d_3		d_1		d_2		d_3	
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed
Stored at 65°-80°F without T.C.N.B.	175.53	140.04	87.44	121.97	88.73	62.27	148.10	128.74	96.15	83.89	85.18	59.05
Stored at 50°-60°F without T.C.N.B.	224.25	172.63	155.85	150.68	52.27	52.27	170.69	145.52	127.13	113.58	90.99	97.12
Stored at 40°F without T.C.N.B.	230.38	185.53	228.45	213.93	213.28	203.60	168.11	148.43	170.69	153.91	206.18	157.78
Stored at 65°-80°F with T.C.N.B.	155.20	178.11	108.42	195.86	14.20	9.68	177.47	153,27	135.52	83,89	67.44	44.53
Stored at 50°-60°F with T.C.N.B.	243.94	141.00	178.43	126.48	54.21	62.60	50.34	68.73	7.42	27.43	15.49	35.82
Stored at 40°F with T.C.N.B.	273.94	202.63	221.67	204.25	208.44	198.76	188.44	147.14	167.14	136.49	214.25	183.27
Mean	217.21	169.99	163.38	168.86	105.19	98.20	150.52	131.97	117.34	99,86	113.26	96.26

S.E. of V x S x D ± 6.15 S.E. of T x V x D x S ± 11.83

APPENDIX 70

YIELD OF WARE

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
Total whole plot	7	10374.477		
Replication	3	425.497	141.832	4.28
Variety (V)	1	9849.646	9849.646	297.47 **
Error 'a'	3	99.334	33.111	
Total sub plot	47	13813.847		
Whole plot i.e. sub plot blocks	7	10374.477		
Date of desprouting (D)	2	2221.734	1110.867	110.99 **
Size of seed tuber (S)	1	13.672	13.672	1.37
Interactions: D x S	2	7.731	3.865	-
V x D	2	873.919	436.959	43.66 **
V x S	1	10.599	10.599	1.06
V x D x S	2	11.465	5.732	-
Error 'b'	30	300.250	10.008	
Total half sub plot	287	25225.982		
Sub plot	47	13813.847		
Treatment (T)	5	5379.817	1075.963	90.53 **
Interactions: T x V	5	2613.038	522.608	43.97 **
T x D	10	368.631	36.863	3.10 **
T x S	5	56.449	11.290	-
T x V x D	10	597.55	59.755	5.03 **
T x V x S	5	90.298	18.060	1.52
T x D x S	10	109.097	10.910	-
T x V x D x S	10	57.977	5.798	-
Error 'c'	180	2139.278	11.885	

** Significant at 1%

APPENDIX 71

NUMBER OF WARE

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
Total whole plot	7	23244.944		
Replication	3	1346.028	448.676	4.00
Variety (V)	1	21562.722	21562.722	192.41**
Error 'a'	3	336.194	112.065	
Total sub plot	47	31206.500		
Whole plot i.e. sub plot block	7	23244.944		
Date of desprouting (D)	2	5282.771	2641.385	124.48**
Size of seed tuber (S)	1	10.889	10.889	-
Interactions: D x S	2	12.798	6.399	-
V x D	2	1968.965	984.482	46.39**
V x S	1	10.889	10.889	-
V x D x S	2	38.633	19.316	-
Error 'b'	30	636.611	21.220	
Total half sub plot	287	62617.500		
Sub plot	47	31206.500		
Treatment (T)	5	17002.875	3400.575	129.44**
Interactions: T x V	5	6589.070	1317.814	50.16**
T x D	10	1160.604	116.060	4.42**
T x S	5	49.236	9.847	-
T x V x D	10	1238.993	123.899	4.72**
T x V x S	5	197.486	39.497	1.50
T x D x S	10	289.327	28.933	1.10
T x V x D x S	10	154.742	15.474	-
Error 'c'	180	4728.667	26.270	

** Significant at 1%

APPENDIX 72

YIELD OF WARE (TONS/ACRE):
TREATMENT x SEED SIZE

Storage Treatment	Seed Size Large	Seed Size Small	Mean
Stored at 65°-80°F without T.C.N.B.	6.126	6.084	6.105
" " 50°-60°F " "	8.082	8.094	8.088
" " 40°F " "	9.384	10.140	9.762
Stored at 65°-80°F with T.C.N.B.	4.596	4.080	4.338
" " 50°-60° " "	2.832	3.120	2.976
" " 40°F " "	8.664	9.672	9.168
Mean	6.614	6.865	

S.E. of Seed size ± 0.152

S.E. of Treatment ± 0.286

S.E. of Treatment x Seed size ± 0.405

APPENDIX 73

NUMBER OF WARE (1000/ACRE):
TREATMENT x SEED SIZE

Storage Treatment	Seed Size		Mean
	Large	Small	
Stored at 65°-80°F without T.C.N.B.	21.24	20.49	20.86
" " 50°-80°F " "	28.18	28.23	28.20
" " 40°F " "	37.27	36.84	37.05
Stored at 65°-80°F with T.C.N.B.	16.78	14.09	15.43
" " 50°-60°F " "	8.98	9.52	9.25
" " 40°F " "	33.93	34.20	34.06
Mean	24.40	23.89	

S.E. of Seed size ± 0.48

S.E. of Treatment ± 0.95

S.E. of Treatment x Seed size ± 1.35

APPENDIX 74

YIELD OF WARE (TONS/ACRE):

TREATMENT x VARIETY x SEED SIZE

Storage Treatment	Arran Pilot			Majestic		
	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean
Stored at 65^{o}-80^{o}F without T.C.N.B.	2.916	3.012	2.964	9.336	9.156	9.246
" " 50^{o}-60^{o}F " "	3.588	3.372	3.480	12.576	12.816	12.696
" " 40^{o}F " "	5.112	4.680	4.896	13.656	15.600	14.628
Stored at 65^{o}-80^{o}F with T.C.N.B.	2.268	2.460	2.364	6.924	5.700	6.312
" " 50^{o}-60^{o}F " "	2.880	2.280	2.580	2.784	3.960	3.372
" " 40^{o}F " "	3.372	4.512	3.942	13.956	14.832	14.394
Mean	3.356	3.386	3.371	9.872	10.344	10.108

S.E. of Variety $\pm$ 0.276
S.E. of Variety x Seed size $\pm$ 0.215
S.E. of Treatment x Variety $\pm$ 0.405
S.E. of Treatment x Variety x Seed Size $\pm$ 0.573

APPENDIX 75

NUMBER OF WARE (1000/ACRE): TREATMENT x VARIETY x SEED SIZE

Storage Treatment	Arran Pilot			Majestic		
	Large Seed	Small Seed	Mean	Large Seed	Small Seed	Mean
Stored at 65°-$80^{\circ}F$ without T.C.N.B.	10.22	10.11	10.16	32.27	30.87	31.57
" " 50°-$60^{\circ}F$ " "	12.80	12.37	12.58	43.56	44.10	43.83
" " $40^{\circ}F$ " "	21.19	19.68	20.43	53.35	53.99	53.67
Stored at 65°-$80^{\circ}F$ with T.C.N.B.	8.71	8.71	8.71	24.84	19.47	22.16
" " 50°-$60^{\circ}F$ " "	10.11	8.17	9.14	7.85	10.86	9.36
" " $40^{\circ}F$ " "	14.84	18.82	16.83	53.02	49.58	57.30
Mean	12.98	12.98	12.98	35.82	34.81	35.31

S.E. of Variety $\pm$ 1.15
S.E. of Variety x Seed size $\pm$ 0.70
S.E. of Treatment x Variety $\pm$ 1.35
S.E. of Treatment x Variety x Seed Size $\pm$ 1.91

APPENDIX 76

YIELD OF WARE (TONS/ACRE): TREATMENT x DATE OF DESPROUTING x SEED SIZE

Storage treatment	Date of desprouting								
	d_1			d_2			d_3		
	Large seed	Small seed	Mean	Large seed	Small seed	Mean	Large seed	Small seed	Mean
Stored at 65°–80°F. without T.C.N.B.	8.802	9.378	9.090	5.274	4.896	5.085	4.302	3.978	4.140
Stored at 50°–60°F. without T.C.N.B.	9.594	9.324	9.459	8.730	.730	8.730	5.922	6.228	6.075
Stored at 40°F. without T.C.N.B.	10.494	11.466	10.980	8.802	10.656	9.729	8.856	8.298	8.577
Stored at 65°–80°F. with T.C.N.B.	6.552	6.732	6.642	5.616	4.518	5.067	1.620	0.990	1.305
Stored at 50°–60°F. with T.C.N.B.	5.238	4.644	4.941	2.286	2.448	2.367	0.972	2.268	1.620
Stored at 40°F. with T.C.N.B.	9.774	11.772	10.773	10.278	9.828	10.053	5.940	7.416	6.678
Mean.	8.409	8.886	8.647	6.831	6.846	6.838	4.602	4.863	4.732

S.E. of Date of desprouting ± 0.186

S.E. of Date of desprouting x seed size ± 0.263

S.E. of Treatment x Date of desprouting ± 0.496

S.E. of Treatment x Date of desprouting x seed size ± 0.702

APPENDIX 77

[illegible] (1 [illegible] ACRE):
TREATMENT x DATE OF DESPROUTING x SEED SIZE

Storage treatment	Date of desprouting								
	d_1			d_2			d_3		
	Large seed	Small seed	Mean	Large seed	Small seed	Mean	Large seed	Small seed	Mean
Stored at 65°-80°F. without T.C.N.B.	31.30	32.37	31.78	16.29	16.46	16.37	16.13	12.74	14.44
Stored at 50°-60°F. without T.C.N.B.	34.20	34.20	34.20	30.81	30.65	30.73	19.52	19.84	19.68
Stored at 40°F. without T.C.N.B.	41.62	40.01	40.82	34.36	37.43	35.90	35.81	33.07	34.44
Stored at 65°-80°F. with T.C.N.B.	25.33	23.71	24.52	20.17	15.00	17.58	4.84	3.55	4.19
Stored at 50°-60°F. with T.C.N.B.	16.94	14.04	15.49	7.10	7.90	7.50	2.90	6.61	4.76
Stored at 40°F. with T.C.N.B.	37.11.	40.98	39.04	39.20	32.91	36.06	25.49	28.72	27.10
Mean.	31.08	30.87	30.97	24.66	23.39	24.02	17.45	17.42	17.43

S.E. of Date of desprouting ± 0.61

S.E. of Date of desprouting x seed size ± 0.85

S.E. of Treatment x Date of desprouting ± 1.65

S.E. of Treatment x Date of desprouting x seed size ± 2.33

APPENDIX 78

YIELD OF WARE (TONS/ACRE): TREATMENT x VARIETY x DATE OF DESPROUTING x SEED SIZE

Storage Treatment	Arran Pilot						Majestic					
	d_1		d_2		d_3		d_1		d_2		d_3	
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed
Stored at 65°-80°F without T.C.N.B.	3.636	3.636	2.196	2.340	2.916	3.060	13.968	15.120	8.352	7.452	5.688	4.896
Stored at 50°-60°F without T.C.N.B.	4.392	4.932	4.428	3.996	1.944	1.188	14.796	13.716	13.032	13.464	9.900	11.268
Stored at 40°F without T.C.N.B.	5.832	5.076	3.348	4.176	6.156	4.788	15.156	17.856	14.256	17.136	11.556	11.808
Stored at 65°-80°F with T.C.N.B.	2.808	3.672	3.492	3.528	0.504	0.180	10.296	9.792	7.740	5.508	2.736	1.800
Stored at 50°-60°F with T.C.N.B.	4.140	2.448	3.528	2.844	0.972	1.548	6.336	6.840	1.044	2.052	0.972	2.988
Stored at 40°F with T.C.N.B.	3.024	5.220	3.312	4.032	3.780	4.284	16.524	18.324	17.244	15.624	8.100	10.548
Mean	3.972	4.164	3.384	3.486	2.712	2.508	12.846	13.608	10.278	10.206	6.492	7.218

S.E. of V x D x S ± 0.372 S.E. of T x V x D x S ± 0.993

APPENDIX 79

NUMBER OF WARE (1000/ACRE):
TREATMENT x VARIETY x DATE OF DESPROUTING x SEED SIZE

Storage Treatment	Arran Pilot						Majestic					
	d_1		d_2		d_3		d_1		d_2		d_3	
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed
Stored at 65°-80°F without T.C.N.B.	12.26	11.62	7.10	9.03	11.29	9.68	50.34	52.92	25.49	23.88	20.97	15.81
Stored at 50°-60°F without T.C.N.B.	14.84	17.10	16.46	15.16	7.10	4.84	53.56	51.30	45.17	46.14	31.94	34.85
Stored at 40°F without T.C.N.B.	24.84	21.62	14.84	16.46	23.88	20.97	58.40	58.40	53.88	58.40	47.75	45.17
Stored at 65°-80°F with T.C.N.B.	11.62	13.23	13.23	12.26	1.29	0.64	39.04	34.20	27.10	17.75	8.39	6.45
Stored at 50°-60°F with T.C.N.B.	15.49	9.36	11.94	10.65	2.90	4.52	18.39	18.71	2.26	5.16	2.90	8.71
Stored at 40°F with T.C.N.B.	12.91	20.33	15.49	18.07	16.13	18.07	61.31	61.63	62.92	47.75	34.85	39.36
Mean	15.33	15.54	13.17	13.60	10.43	9.79	46.84	46.19	36.14	33.18	24.47	25.06

S.E. of V x D x S ± 1.21 S.E. of T x V x D x S ± 3.30

APPENDIX 80

YIELD OF SEED TUBERS

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
Total whole plot	7	1089.308		
Replication	3	563.980	189.660	17.062 *
Variety (V)	1	486.980	486.980	43.809**
Error 'a'	3	33.348	11.116	
Total sub plot	47	3296.430		
whole plot i.e. sub plot block	7	1089.308		
Date of desprouting (D)	2	1073.738	539.369	73.705**
Size of seed tuber (S)	1	282.031	282.031	41.154**
Interactions: D x S	2	70.432	35.216	5.139 *
V x D	2	497.412	248.706	36.291**
V x S	1	6.421	6.421	-
V x D x S	2	66.489	33.244	4.851 *
Error 'b'	30	205.599	6.853	
Total half sub plot	287	16570.805		
Sub plot	47	3296.430		
Treatment (T)	5	8044.367	1608.873	198.553**
Interactions: T x V	5	1026.630	205.326	25.339**
T x D	10	1941.481	194.148	23.960**
T x S	5	92.136	18.427	2.274 *
T x V x D	10	373.681	37.368	4.612**
T x V x S	5	207.365	41.473	5.118**
T x D x S	10	76.917	7.692	-
T x V x D x S	10	53.194	5.319	-
Error 'c'	180	1458.604	8.103	

** Significant at 1%   * Significant at 5%

APPENDIX 81

NUMBER OF SEED TUBERS

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
Total whole plot	7	56097.708		
Replication	3	11380.291	3793.430	12.513 *
Variety (V)	1	43808.000	43808.000	144.514 **
Error 'a'	3	909.417	303.139	
Total sub plot	47	126454.653		
Whole plot i.e. sub plot block	7	56097.708		
Date of desprouting (D)	2	32780.007	16390.003	70.679 **
Size of seed tuber (S)	1	7160.055	7160.055	30.876 **
Interactions: D x S	2	2867.424	1433.712	6.183 **
V x D	2	17939.437	8969.718	38.680 **
V x S	1	51.681	51.681	-
V x D x S	2	2601.549	1300.774	5.609 **
Error 'b'	30	6956.792	231.893	
Total half sub plot	287	430108.986		
Sub plot	47	126454.653		
Treatment (T)	5	176210.778	35242.156	187.694 **
Interactions: T x V	5	29699.208	5939.842	31.635 **
T x D	10	43649.951	4364.995	23.247 **
T x S	5	2507.903	501.581	2.671 *
T x V x D	10	7254.605	725.460	3.864 **
T x V x S	5	5887.694	1177.539	6.271 **
T x D x S	10	2480.868	248.087	1.321
T x V x D x S	10	2165.826	216.583	1.153
Error 'c'	180	33797.500	187.764	

** Significant at 1% * Significant at 5%

APPENDIX 82

YIELD OF SEED TUBERS (TONS/ACRE): TREATMENT x SEED SIZE

Storage Treatment	Seed Size		Mean
	Large	Small	
Stored at 65°-80°F without T.C.N.B.	5.580	4.620	5.100
" " 50°-60°F " "	7.056	6.138	6.597
" " 40°F " "	12.324	10.032	111.178
Stored at 65°-80°F with T.C.N.B.	5.850	5.340	5.595
" " 50°-60°F " "	4.014	3.540	3.777
" " 40°F " "	12.606	10.920	11.763
Mean	7.905	6.765	

S.E. of Seed-size ± 0.125

S.E. of Treatment ± 0.237

S.E. of Treatment x Seed size ± 0.335

APPENDIX 83

NUMBER OF SEED TUBERS (1000/ACRE): TREATMENT x SEED SIZE

Storage Treatment	Seed Size		Mean
	Large	Small	
Stored at 65^{o}-80^{o}F without T.C.N.B.	62.81	50.77	56.79
" " 50^{o}-60^{o}F " "	78.03	57.44	72.73
" " 40^{o}F " "	132.08	110.78	121.43
Stored at 65^{o}-80^{o}F with T.C.N.B.	62.87	61.47	62.17
" " 50^{o}-60^{o}F " "	48.67	40.49	44.58
" " 40^{o}F " "	139.18	115.46	127.32
Mean	87.27	74.40	

S.E. of Seed size $\pm$ 1.64

S.E. of Treatment $\pm$ 2.55

S.E. of Treatment x Seed size $\pm$ 3.61

APPENDIX 84

YIELD OF SEED TULIPS (TONS/ACRE): TREATMENT x DATE OF DESPROUTING x SEED SIZE

Storage treatment	Date of desprouting								
	d_1			d_2			d_3		
	Large seed	Small seed	Mean	Large seed	Small seed	Mean	Large seed	Small seed	Mean
Stored at 65°-80°F. without T.C.N.B.	8.172	6.048	7.110	4.266	4.590	4.428	4.302	3.222	3.762
Stored at 50°-60°F. without T.C.N.B.	10.638	8.658	9.648	6.912	6.156	6.534	3.618	3.600	3.609
Stored at 40°F. without T.C.N.B.	11.448	8.964	10.206	12.474	10.026	11.250	13.050	11.106	12.078
Stored at 65°-80°F. with T.C.N.B.	8.622	8.478	8.550	6.642	6.300	6.471	2.286	1.242	1.764
Stored at 50°-60°F. with T.C.N.B.	7.110	4.914	6.012	3.276	3.348	3.312	1.656	2.358	2.007
Stored at 40°F. with T.C.N.B.	12.600	9.900	11.250	11.070	10.350	10.710	14.198	12.510	13.329
Mean.	9.765	7.827	8.776	7.440	6.795	7.117	6.510	5.673	6.091

S.E. of Date of desprouting 0.154

S.E. of Date of desprouting x seed size 0.218

S.E. of Treatment x Date of desprouting 0.410

S.E. of Treatment x Date of desprouting x seed size 0.579

APPENDIX 85

NUMBER OF SEED TUBERS (1000/ACRE): TREATMENT x DATE OF DESPROUTING x SEED SIZE

Storage treatment	Date of desprouting								
	d_1			d_2			d_3		
	Large seed	Small seed	Mean	Large seed	Small seed	Mean	Large seed	Small seed	Mean
Stored at 65°-80°F. without T.C.N.B.	93.25	67.60	80.42	46.35	50.98	48.36	48.24	33.72	40.98
Stored at 50°-60°F. without T.C.N.B.	119.87	94.06	106.96	76.95	68.89	72.92	37.27	39.36	38.32
Stored at 40°F. without T.C.N.B.	124.71	98.90	111.80	133.74	112.93	123.34	137.78	120.51	129.15
Stored at 65°F-80°F. with T.C.N.B.	93.57	95.02	95.30	70.66	74.37	72.52	24.36	15.00	19.68
Stored at 50°-60°F. with T.C.N.B.	85.83	57.92	71.87	44.53	38.56	41.54	15.65	25.01	20.33
Stored at 40°F. with T.C.N.B.	146.33	103.90	125.11	122.29	110.83	116.56	148.91	131.65	140.28
Mean	110.59	86.23	98.41	82.52	76.09	79.30	68.70	60.38	64.79

S.E. of Date of desprouting ± 2.00

S.E. of Date of desprouting x seed size ± 2.84

S.E. of Treatment x Date of desprouting ±4.41.

S.E. of Treatment x Date of desprouting x seed size ± 6.24.

APPENDIX 86

YIELD OF SEED TUBERS (TONS/ACRE):
TREATMENT x VARIETY x DATE OF DESTRUCTING x SEED SIZE

Storage Treatment	Arran Pilot						Majestic					
	d_1		d_2		d_3		d_1		d_2		d_3	
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed
Stored at 65°-80°F without T.C.N.B.	7.776	5.904	3.528	4.608	3.996	3.276	8.568	6.192	5.004	4.572	4.608	3.168
Stored at 50°-60°F without T.C.N.B.	12.024	8.712	7.200	6.732	2.412	2.520	9.252	8.604	6.624	5.580	4.824	4.680
Stored at 40°F without T.C.N.B.	13.716	10.800	15.120	12.816	13.752	12.744	9.180	7.128	9.828	7.236	12.348	9.468
Stored at 65°-80°F with T.C.N.B.	6.552	7.812	5.796	8.532	0.612	0.396	10.692	9.144	7.483	4.068	3.960	2.088
Stored at 50°-60°F with T.C.N.B.	11.700	6.912	6.372	5.184	2.412	2.448	2.520	2.916	0.180	1.512	0.900	2.268
Stored at 40°F with T.C.N.B.	15.408	11.988	12.816	13.644	13.032	11.772	9.792	7.812	9.324	7.056	15.264	13.248
Mean	11.196	8.688	8.472	8.586	6.036	5.526	8.334	6.966	6.408	5.004	6.984	5.820

S.E. of V x D x S ± 0.307 S.E. of T x V x D x S ± 0.820

APPENDIX 87

NUMBER OF SEED TUBERS (1000/ACRE):
TREATMENT x VARIETY x DATE OF DESPROUTING x SEED SIZE

Storage Treatment	Arran Pilot						Majestic					
	d_1		d_2		d_3		d_1		d_2		d_3	
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed
Stored at 65°-80°F without T.C.N.B.	102.28	71.95	42.59	60.98	46.46	35.82	84.22	63.24	51.30	40.98	50.01	31.62
Stored at 50°-60°F without T.C.N.B.	149.72	108.74	89.70	82.92	27.43	30.33	90.02	79.38	64.21	54.85	47.11	48.40
Stored at 40°F without T.C.N.B.	159.40	128.74	173.59	152.62	154.23	152.00	90.02	69.05	93.90	73.24	121.32	89.06
Stored at 65°-80°F with T.C.N.B.	82.28	98.74	62.92	104.87	6.78	5.48	104.87	91.31	78.41	43.88	41.95	24.52
Stored at 50°-60°F with T.C.N.B.	149.07	83.89	86.80	63.24	22.59	30.33	22.59	31.94	2.26	13.87	8.71	19.68
Stored at 40°F with T.C.N.B.	191.34	136.81	153.91	150.36	146.49	137.78	101.32	70.99	90.67	71.31	151.33	125.52
Mean	139.02	104.81	101.59	102.50	63.33	65.29	82.17	67.65	63.46	49.69	70.07	56.47

S.E. of V x D x S ± 4.01 S.E. of T x V x D x S ± 8.84

EXPERIMENT 5 - APPENDIX 88 to 96

APPENDIX 88

WEIGHT (GM.) OF TUBERS (25 TUB.) AND SPROUTS AT THE TIME OF DESPROUTING

Storage Treatment	Initial wt. (gm) of 25 tubers	Wt. (gm.) of tuber and sprout at the time of first desprout		Wt. (gm.) of tuber and sprout at the time of second desprout		Wt. (gm.) of tuber and sprout at the time of planting	
		Tuber	Sprout	Tuber	Sprout	Tuber	Sprout
8 weeks at 40°F; 8 weeks at 50°-60°F; 7 weeks at 40°F.	2526.0	2507	-	2277.0	204.69	2261.0	-
8 weeks at 40°F; 8 weeks at 70°-80°F; 7 weeks at 40°F	2571.0	2552	-	2400.0	108.69	2392.0	-
8 weeks at 40°F; 15 weeks at 50°-60°F	2378.0	2359	-	-	-	2000.0	314.0
8 weeks at 40°F; 15 weeks at 65°-80°F	2427.0	2413	-	-	-	2144.0	194.5
8 weeks at 50°-60°F; 15 weeks at 40°F	2658.0	2538.0	74.20	-	-	2509.0	9.10
8 weeks at 65°-80°F; 15 weeks at 40°F	2504.0	2389.0	52.50	-	-	2340.0	26.80
16 weeks at 40°F; 7 weeks at 50°-60°F	2319.0	-	-	2298.0	1.0	2009.0	262.0
16 weeks at 40°F; 7 weeks at 65°-80°F	2562.0	-	-	2529.0	1.0	2383.0	105.4
16 weeks at 50°-60°F; 7 weeks at 40°F	2442.0	-	-	2149.0	265.10	2136.0	-
16 weeks at 65°-80°F; 7 weks at 40°F	2356.0	-	-	2050.0	194.79	2037.0	-
Throughout (23 weeks) at 50°-60°F	2509.0	-	-	-	-	2073.0	337.5
Throughout (23 weeks) at 65°-80°F	2513.0	-	-	-	-	2076.0	299.20
Throughout (23 weeks) at 40°F	2457.0	-	-	-	-	2379.0	10.0
Throughout (23 weeks) at 40oF	2436.0	-	-	-	-	2351.0	12.20

N.B. First desprouting on 8.1.61   Second Desprouting on 6.3.61.

APPENDIX 89

EFFECT OF DIFFERENT STORAGE TREATMENTS ON THE SHRINKAGE OF SEED TUBERS

Storage Treatment	[1] First Desprout			[2] Second Desprout			[3] Third Desprout at the time of planting			Weight Loss during the Total Storage Period		
	Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt. (%)	Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt. (%)	Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt. (%)	Loss in wt. (%) due to Sprout	Loss in wt. (%) due to Transpiration and Respiration	Total loss in wt. (%)
8 weeks at 40°F; 8 weeks at 50°-60°F; 7 weeks at 40°F	-	0.75	0.75	8.10	1.01	9.11	-	0.63	0.63	8.10	2.39	10.49
8 weeks at 40°F; 8 weeks at 65°-80°F; 7 weeks at 40°F	-	0.74	0.74	4.23	1.68	5.91	-	0.31	0.31	4.23	2.73	6.96
8 weeks at 40°F; 15 weeks at 50°-60°F	-	0.80	0.80				13.20	1.89	15.09	13.20	2.69	15.89
8 weeks at 40°F; 15 weeks at 65°-80°F	-	0.58	0.58				8.01	3.07	11.08	8.01	3.65	11.66
8 weeks at 50°-60°F; 15 weeks at 40°F	2.79	1.72	4.51				0.34	0.75	1.09	3.13	2.47	5.60
8 weeks at 65°-80°F; 15 weeks at 40°F	2.10	2.49	4.59				1.07	0.89	1.96	3.17	3.38	6.55
16 weeks at 40°F; 7 weeks at 50°-60°F;				0.04	0.86	0.90	11.30	1.17	12.47	11.34	2.03	13.37
16 weeks at 40°F; 7 weeks at 65°-80°F				0.04	1.25	1.29	4.11	1.59	5.70	4.15	2.84	6.99
16 weeks at 50°-60°F; 7 weeks at 40°F				10.85	1.15	12.00	-	0.53	0.53	10.85	1.68	12.53
16 weeks at 65°-80°F; 7 weeks at 40°F				8.27	4.72	12.99	-	0.55	0.55	8.27	5.27	13.54
Throughout (23 weeks) at 50°-60°F							13.45	3.93	17.38	13.45	3.93	17.38
Throughout (23 weeks) at 65°-80°F							11.91	5.48	17.39	11.91	5.48	17.39
Throughout (23 weeks) at 40°F							0.41	2.76	3.17	0.41	2.76	3.17
Throughout (23 weeks) at 40°F							0.51	2.99	3.49	0.51	2.99	3.49

1 = 59 days (8. 1.61)

2 = 116 days (i.e. 57 days after first desprout) [6. 3.61].

3 = 166 days (i.e. 50 days after second desprout) [25. 4.61].

APPENDIX 90

EFFECT OF DIFFERENT STORAGE TREATMENTS ON AVERAGE NUMBER OF DAYS REQUIRED FOR PLANT EMERGENCE AND FINAL STAND

Period of heat treatment	Average number of days required in the emergence of plant		Final stand (°/o) of plant	
	50°-60°F	65°-80°F	50°-60°F	65°-80°F
1. First 8 weeks heat treatment and then 15 weeks at 40°F.	34.81	34.58	100°/o	100°/o
2. First 8 weeks at 40°F and then 8 weeks heat treatment and then 7 weeks at 40°F.	33.37	32.53	100°/o	100°/o
3. First 16 weeks at 40°F and then 7 weeks heat treatment.	28.55	30.06	100°/o	100°/o
4. First 16 weeks heat treatment and then 7 weeks at 40°F.	34.79	35.42	100°/o	100°/o
5. First 8 weeks at 40°F and then 15 weeks heat treatment.	26.15	27.31	100°/o	100°/o
6. Throughout (23 weeks) heat treatment.	31.75	34.25	60°/o	70°/o
Mean	31.57	32.36		
7. Throughout (23 weeks) at 40°F	31.35	32.52	100°/o	100°/o

APPENDIX 91

EFFECT OF MEDIUM (50°-60°F) AND HIGH (65°-80°F) TEMPERATURE STORAGE ON THE "GERMINATION RATE INDEX"

Period of Heat Treatment	Germination Rate Index	
	50°-60°F	65°-80°F
1. First 8 weeks heat treatment and then 15 weeks at 40°F.	0.228	0.225
2. First 8 weeks at 40°F and then 8 weeks heat treatment and then 7 weeks at 40°F.	0.294	0.328
3. First 16 weeks at 40°F and then 7 weeks heat treatment.	0.509	0.475
4. First 16 weeks heat treatment and then 7 weeks at 40°F.	0.220	0.150
5. First 8 weeks at 40°F and then 15 weeks heat treatment.	0.625	0.575
6. Throughout (23 weeks) heat treatment.	0.361	0.167
Mean	0.373	0.320
7. Throughout (23 weeks) at 40°F.	0.375	0.320

S.E. of Temperature (i.e. medium vs high) $\pm$ 0.019

S.E. of Heat Treatment x Period $\pm$ 0.046

APPENDIX 92

GERMINATION RATE INDEX

(ANALYSIS OF VARIANCE)

Factor		d.f	S.Sq.	M.S.Sq.	Variance Ratio
Replication		4	0.088975	0.022244	2.06
Treatment		13	1.465697	0.112746	10.44 **
(i)	Temperature i.e. 50°-60°F vs 65°-80°F	1	0.041765	0.041765	3.87
(ii)	Period of heat treatment	6	1.339842	0.223307	20.68 **
(iii)	Temperature x period of heat treatment	6	0.084090	0.014015	1.29
Error		52	0.561581	0.010800	
Total		69	2.116253		

** Significant at 1%

APPENDIX 93

EFFECT OF DIFFERENT STORAGE TREATMENTS ON THE DRY MATTER PRODUCTION (GM) OF TUBERS PER PLANT AT VARIOUS STAGES OF PLANT DEVELOPMENT

Period of Heat Treatment	50°-60°F				65°-80°F			
	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4
1. First 8 weeks heat treatment and then 15 weeks at 40°F.	8.6	76.4	185.4	245.8	9.2	88.6	147.0	242.4
2. First 8 weeks at 40°F and then 8 weeks heat treatment and then 7 weeks at 40°F.	12.4	93.6	176.0	227.0	13.6	74.2	157.8	272.6
3. First 16 weeks at 40°F and then 7 weeks heat treatment.	22.8	103.4	167.8	223.2	11.2	101.8	125.4	190.0
4. First 16 weeks heat treatment and then 7 weeks at 40°F.	9.5	69.4	158.2	166.2	4.98	14.10	87.4	128.8
5. First 8 weeks at 40°F and then 15 weeks heat treatment.	26.3	66.4	159.0	248.6	25.2	128.4	192.0	214.4
6. Throughout (23 weeks) heat treatment.	7.1	9.9	29.2	27.7	1.8	6.0	15.8	21.2
7. Throughout (23 weeks) at 40°F.	8.7	97.0	158.4	301.2	8.5	91.0	194.2	266.6

S.E. Temperature x Period x Date of lifting $\pm$ 15.9

APPENDIX 94

EFFECT OF DIFFERENT STORAGE TREATMENTS ON THE DRY MATTER PRODUCTION (GMS) OF TUBER PER PLANT AT VARYING STAGES OF GROWTH

(ANALYSIS OF VARIANCE)

Factor	d.f	S.Sq.	M.S.Sq.	Variance Ratio
Replication	4	6473.99	1618.50	-
Date of lifting	3	1368540.32	456180.11	258.14 **
Error 'a'	12	21206.19	1767.18	
Treatment	13	503303.87	33715.68	30.54 **
(i) Temperature	1	6312.98	6312.98	4.98 *
(ii) Period of heat treatment	6	477402.84	79567.14	62.76 **
(iii) Temperature x period of heat treatment	6	19588.05	3264.67	2.57 *
Treatment x Date of Lifting	39	279762.76	7173.40	5.66 **
(i) Temperature	3	5294.79	1764.93	1.39
(ii) Period of heat treatment	18	241099.35	13394.41	10.56 **
(iii) Temperature x period of heat treatment	18	33368.62	1853.81	1.46
Error 'b'	208	263680.08	1267.69	
Total	279	2442967.21		

** Significant at 1%   * Significant at 5%

APPENDIX 95

EFFECT OF DIFFERENT STORAGE TREATMENTS ON THE DRY MATTER PRODUCTION (GM) OF FOLIAGE PER PLANT AT VARIOUS STAGES OF PLANT DEVELOPMENT

Period of Heat Treatment	50°–60°F				65°–80°F			
	l_1	l_2	l_3	l_4	l_1	l_2	l_3	l_4
1. First 8 weeks heat treatment and then 15 weeks at 40°F.	24.2	57.2	61.0	28.6	20.8	50.2	54.2	18.8
2. First 8 weeks at 40°F and then 8 weeks heat treatment and then 7 weeks at 40°F.	19.8	60.4	55.0	19.2	24.8	46.4	47.2	22.6
3. First 16 weeks at 40°F and then 7 weeks heat treatment.	27.6	49.6	46.0	19.6	15.8	40.8	38.4	23.2
4. First 16 weeks heat treatment and then 7 weeks at 40°F.	17.0	40.0	54.2	11.8	13.7	16.1	39.8	24.4
5. First 8 weeks at 40°F and then 15 weeks heat treatment.	25.9	32.8	41.0	24.5	32.8	54.8	48.0	14.6
6. Throughout (23 weeks) heat treatment.	1.8	4.0	5.2	2.6	0.9	5.4	8.6	3.2
7. Throughout (23 weeks) at 40°F.	26.2	60.2	52.4	24.4	25.5	56.4	58.4	24.6

APPENDIX 96

EFFECT OF DIFFERENT STORAGE TREATMENTS ON THE NUMBER AND SIZE OF TUBERS AT DIFFERENT STAGES OF PLANT DEVELOPMENT

Period of Heat Treatment	50°-60°F																				65°-80°F																			
	Days after planting																				Days after planting																			
	64					85					103					126					64					85					103					126				
	Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total	Size Limits (cm.) of tuber				Total
	0-1	1-3	3-5	>5		0-1	1-3	3-5	>5		0-1	1-3	3-5	>5		0-1	1-3	3-5	>5		0-1	1-3	3-5	>5		0-1	1-3	3-5	>5		0-1	1-3	3-5	>5		0-1	1-3	3-5	>5	
First 8 weeks heat treatment and then 15 weeks at 40°F	9.0	15.0	-	-	24.0	4.0	3.6	9.4	1.0	18.0	0.6	4.8	7.8	2.8	16.0	0.2	3.2	9.0	4.2	16.6	12.4	13.6	-	-	26.0	4.4	9.4	11.2	1.0	26.0	2.0	7.8	6.4	1.4	17.6	0.2	5.8	10.2	3.2	19.4
First 8 weeks at 40°F and then 8 weeks heat treatment and then 7 weeks at 40°F	6.8	7.6	0.8	-	15.2	3.4	5.8	10.8	0.6	20.6	1.0	5.0	6.0	3.2	15.2	0.4	3.0	4.2	4.4	12.0	6.4	12.0	0.4	-	18.8	2.0	4.0	9.2	0.6	15.8	2.0	7.4	7.6	2.0	19.0	-	5.8	11.20	3.0	20.0
First 16 weeks at 40°F and then 7 weeks heat treatment	7.6	11.6	1.4	-	20.6	1.4	3.6	8.4	1.6	15.0	1.4	2.8	6.6	2.6	13.4	0.8	5.6	8.4	2.6	17.4	7.0	4.8	1.4	-	13.2	2.6	5.8	9.4	3.0	20.8	1.2	4.4	6.2	0.8	12.6	0.2	5.6	7.4	2.2	15.4
First 16 weeks heat treatment and then 7 weeks at 40°F	14.2	8.0	0.6	-	22.8	0.2	4.8	9.8	0.2	15.0	1.0	8.0	7.6	1.6	18.2	-	5.2	8.0	1.6	14.8	13.0	9.8	-	-	22.8	2.4	7.2	2.2	-	11.8	0.8	3.4	5.8	0.4	10.4	0.4	3.2	7.8	0.8	12.2
First 8 weeks at 40°F and then 15 weeks heat treatment	7.4	9.6	2.8	-	19.8	1.2	7.2	6.4	1.0	15.8	0.6	6.6	4.6	2.4	14.2	0.4	6.6	9.4	3.0	19.4	10.2	14.0	1.8	-	26.0	6.0	3.6	14.4	1.2	25.2	1.4	3.4	6.6	4.0	15.4	0.6	5.6	7.4	2.8	16.4
Throughout (23 weeks) heat treatment	3.0	5.8	0.2	-	9.0	0.8	5.2	0.8	-	6.8	0.6	5.8	1.4	0.2	8.0	-	3.4	0.4	0.4	4.2	1.4	1.8	0.2	-	3.4	0.6	3.0	1.0	-	4.6	1.6	4.8	0.6	-	7.0	-	1.2	1.4	-	2.6
Throughout (23 weeks) at 40°F	6.8	10.8	0.6	-	18.2	3.8	6.2	13.8	1.0	24.8	1.6	5.0	9.0	1.0	16.6	-	5.6	8.2	5.4	19.2	11.6	12.2	-	-	23.8	3.2	3.8	9.0	1.8	17.8	0.4	5.8	8.6	2.2	17.0	0.8	4.2	9.8	4.2	19.0